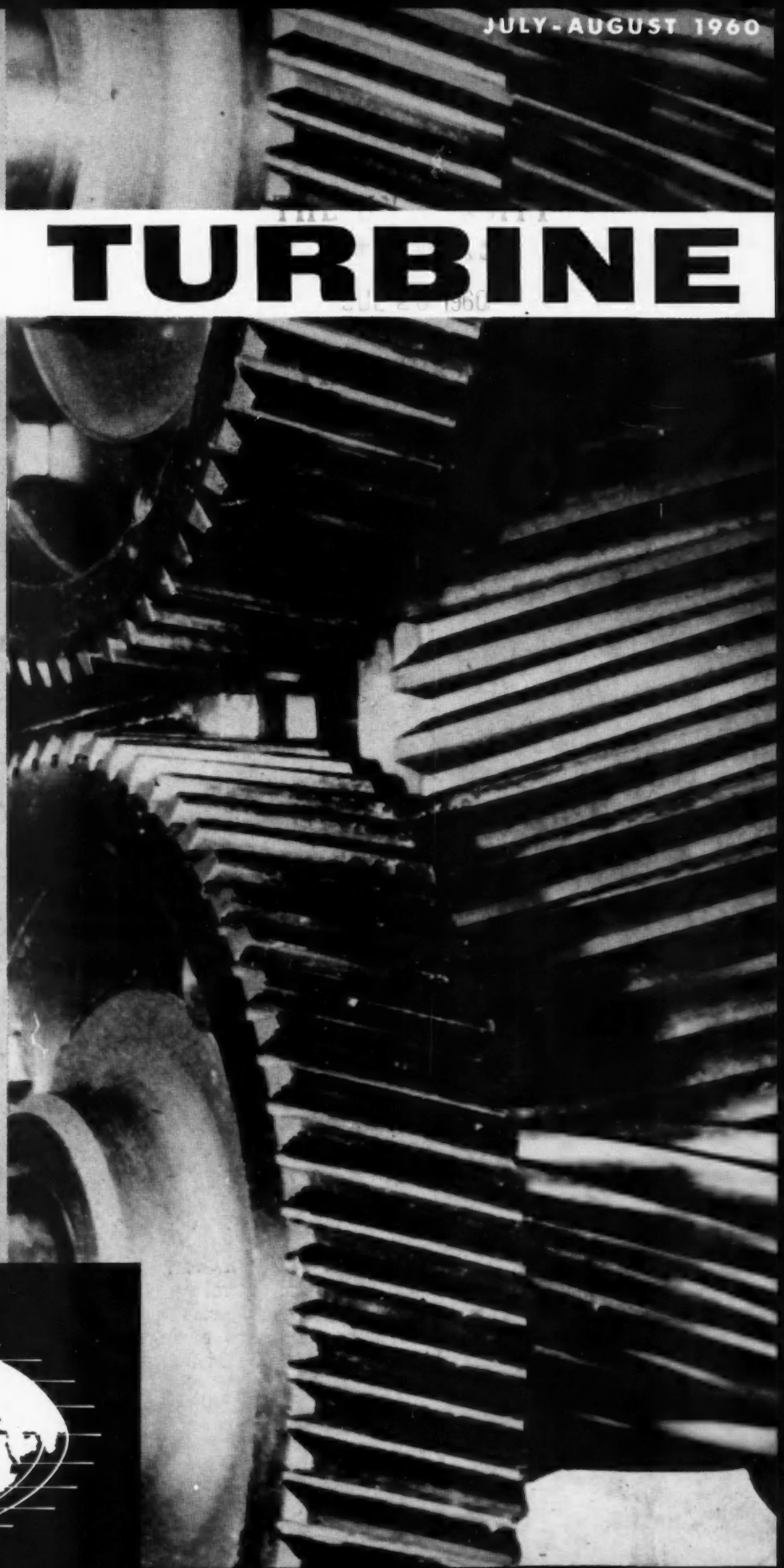
JULY-AUGUST 1960

GAS TURBINE



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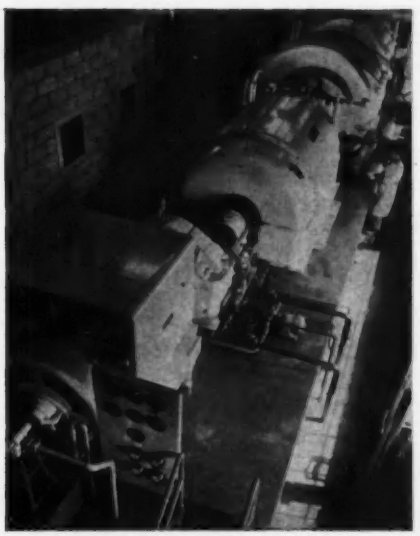

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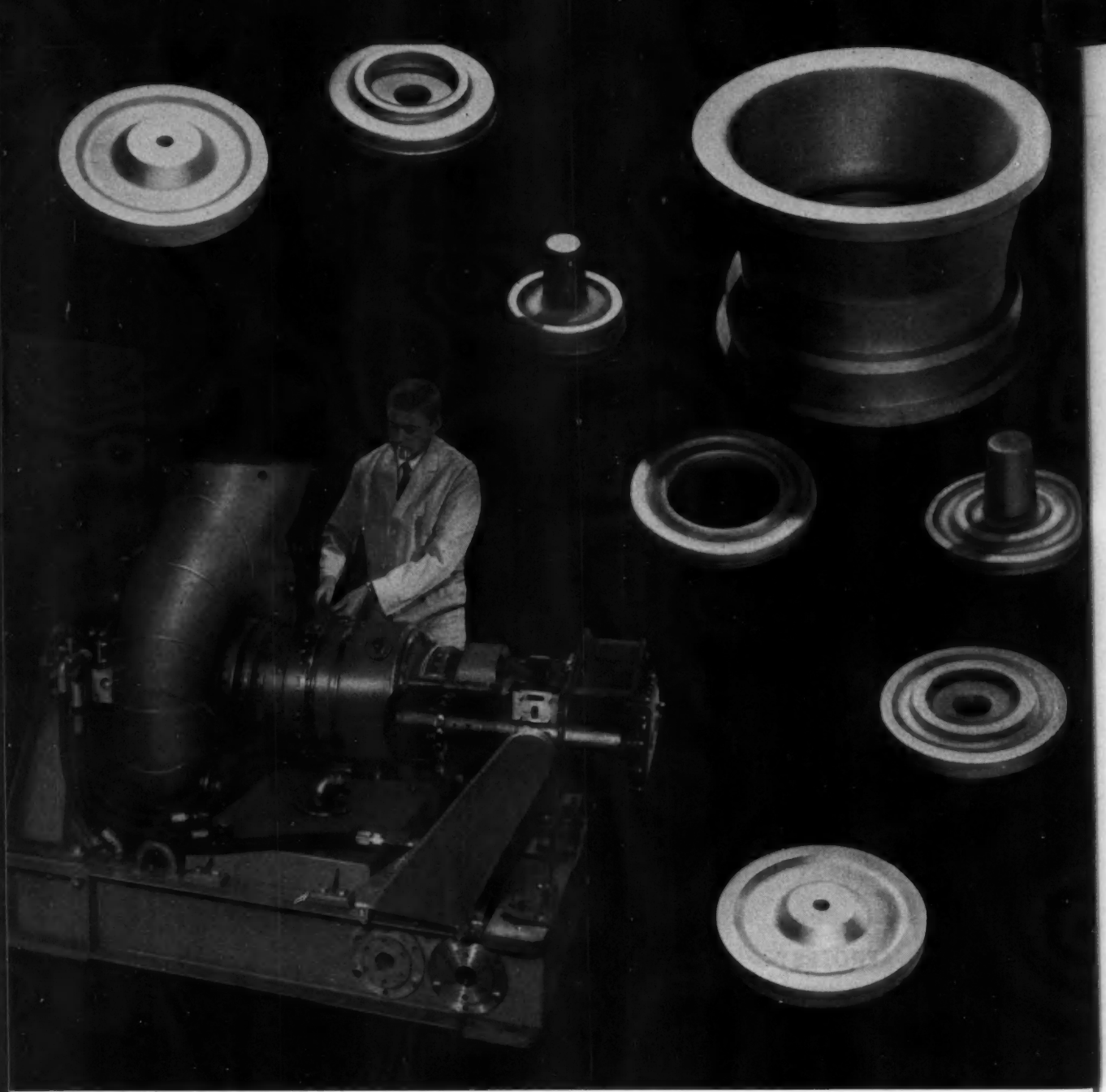
For more information write in No. 36



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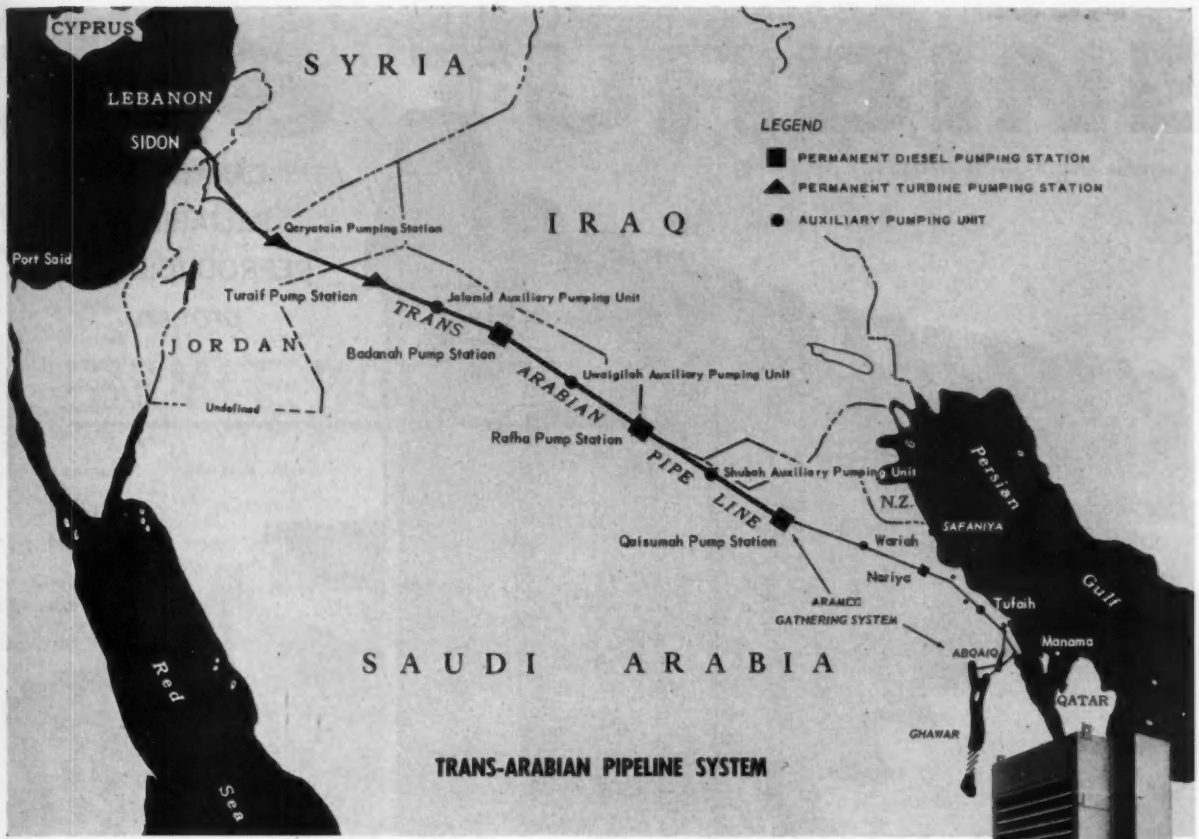

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GAS TURBINE

VOLUME 1, No. 4, July-August, 1960

Editor Brian P. Emerson

Consulting Editor R. Tom Sawyer

Associate Editor Bruce Miller, Jr.

Contributing Editors

Nuclear F. L. Jackson
Industrial J. W. Sawyer
Marine J. W. Sawyer
Automotive F. L. Schwartz
Aviation Dr. Otis Lancaster

President James E. Jones

Publisher G. Renfrew Brighton

Asst. Publisher Wilbur W. Young

Circulation Fulfillment Mgr. Adele Hoppe

Production Mgr. W. B. Williamson

Art Director Leonard Wahlgren

Representation

Mid-West
Chet Mozden, Dist. Mgr.
Frank Wenzel, Dist. Mgr.
605 N. Michigan Ave.
Chicago 1, Ill.
Rm. 206
Tel: MIchigan 2-5050

Pacific Coast
Pugh & Rider Associates
404 Halliburton Building
1709 W. Eighth Street
Los Angeles 17, Calif.
Tel: HUbbard 3-0537
Hunter Vinton
16 Crescent Drive
Palo Alto, Calif.
Tel: DAvenport 5-4815

South-West
The Runnels Company
Ralph Runnels
5210 Morningside Dr.
Houston 5, Texas
Tel: JAckson 4-6633

Great Britain, France, Scandinavia
John Ashcraft
9 Curzon Street
London, W.1, England

Germany
Linder Press Union GmbH.
Wittelsbacher Alle 60
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for turbine engine fuel control

simplify with AC

Now available . . . the first *single unit* small turbine engine fuel control. The AC Model 300 Fuel Control is suitable for turbine engines in the 200 to 500 h.p. class, and can be easily modified for use on other engine power ranges.

A six-pound package only slightly over six inches in length, the Model 300 has all the necessary controls for operating a turbine engine. Because of its straightforward design, there is no need for complex servo actuating systems. Actually, it has only one-half the number of parts used in a conventional fuel control.

This extremely clean design gives not only low cost but a great increase in reliability. Sensitivity to dirt is greatly lessened, permitting the use of a screen type fuel strainer.

If you are engaged in turbine engine development, AC would welcome the opportunity to share its knowledge of fuel control design and work with you to tailor a power control system to your specific needs.

THE MODEL 300 INCORPORATES ALL OF THESE FEATURES IN ONE UNIT!

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- acceleration fuel flow scheduler
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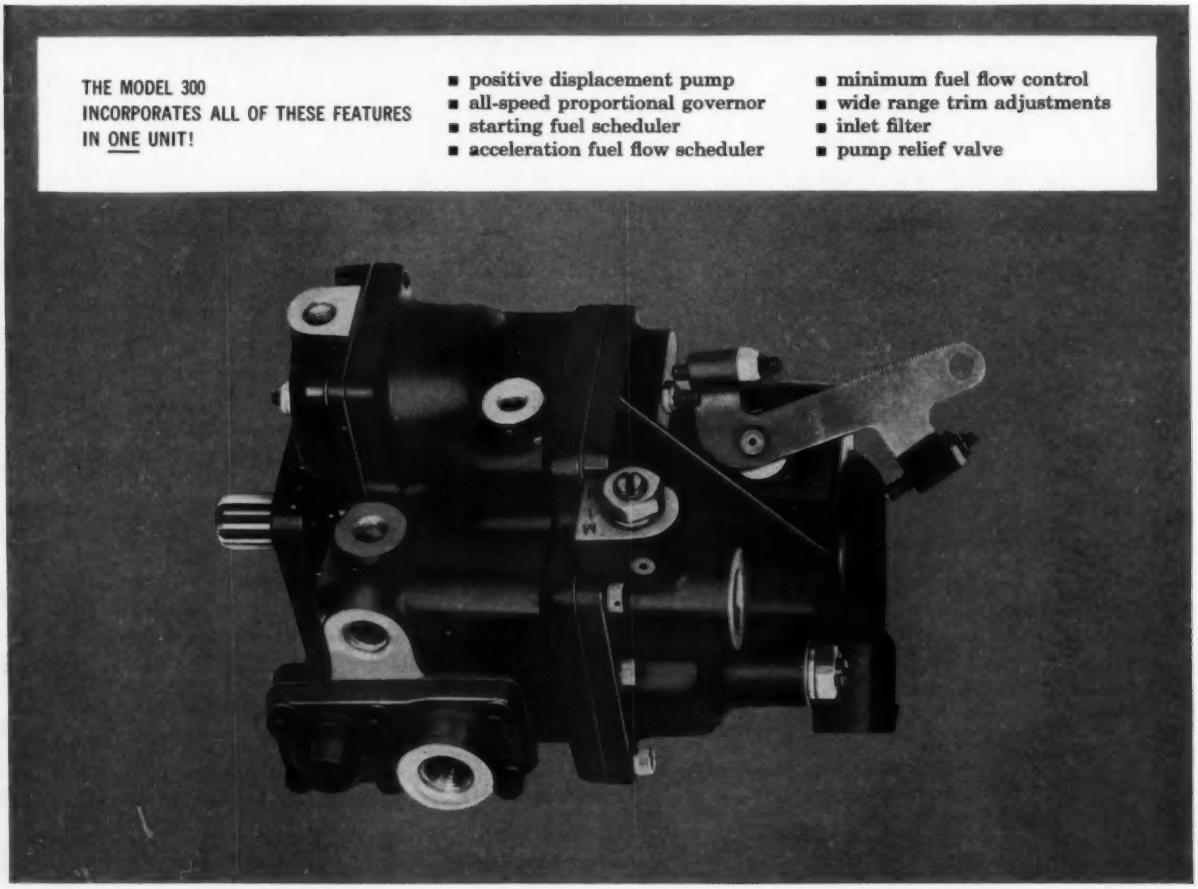

FOR MORE DETAILS ON THE MODEL 300 Fuel Control, Product Bulletin EC-59-5 is available from the Sales Department, AC Spark Plug—the Electronics Division of General Motors, Box 622, Milwaukee 1, Wisconsin.

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GT EDITORIALLY SPEAKING

Proper Application Comes First

History tells us that when a new type of prime mover becomes practical it moves in like the tide—nothing can stop it. But it is possible to hinder its acceptance. Two things will do it—improper application and poor maintenance. Arguing from different viewpoints and backgrounds, people will champion each as being most important. Let's put first things first. Speaking mathematically, maintenance is a function of application. There may be a hundred different applications for a specific gas turbine, all legitimate and economically sound. Yet a high degree of maintenance can be inherent in one application, a low degree in another. So maintenance is a dependent variable of installation. Maintenance is also dependent on the times and the products available. G. L. Morris of Brown & Root, Inc, lent me a fascinating book, "Engineer's Handy-Book", published in 1883. The book refered to only one engine, the steam engine. Even the steam turbine was not yet commercial. Castor oil was the only good lubricant, "No. 1 lard" and "tallow" were commonly used. Yet in this almost 80 years, while maintenance has changed, the principle of proper application has not. Then there's the factor of opinion. Almost 40 years ago, I worked in the 59th Street power station in New York City. We had a mixed bag of steam piston and turbine engines. I heard the maintenance arguments then. Later they turned to steam vs diesels. But application was still the key to good operation. Maintenance alone, no matter how good, will not put the gas turbine across. Most important is to put the gas turbine in its proper application where it can provide the largest return on dollars invested. For every 100 good applications today the future will hold 1000 for this new versatile power unit—the gas turbine. Properly applied, maintenance will fall in line. So as not to hinder the tide of acceptance, let's concentrate on application first—making sure that it's the right job for the gas turbine and that the gas turbine installed is right for the job. It's the surest way to get customer acceptance and future business.

R. Tom Sawyer

Auxiliary Gas Turbines becoming a prime power source for industry

Helmut Schelp, chief engineer, AiResearch Manufacturing Division of Arizona, Phoenix, surrounded by typical gas turbines now in production ranging in size from 30 to 850 hp. Clockwise from the top: GTC 85-28 GTCP 105 • GTP 70-6 • GTP 30-1 • GTP 70-10 • GTU 85-2.

AiResearch Gas Turbine Engines, the most widely used power source for the starting, air conditioning, cooling and heating of jet aircraft, now are becoming a prime power source for industry.

Easier to maintain because of few moving parts, these lightweight gas turbine engines develop more horsepower per pound of weight and size than any other engine. Achieving their greatest efficiency at maximum speeds, they run on almost any fuel and start immediately in any weather.

Future prime power applications of AiResearch gas turbines for industry: earthmoving equipment; small independent generator plants; marine use; helicopters and small conventional aircraft; emergency power plants; air conditioning, heating and refrigeration; atomic energy (closed cycle gas turbine with atomic energy heat source).

First to design and develop a successful small gas turbine engine, Garrett is the world's largest manufacturer of lightweight turbomachinery – having delivered more than 200,000 units, including 9000 gas turbines of all types ranging from 30 to 850 hp. Through its AiResearch Manufacturing Divisions, The Garrett Corporation is now offering this experience to all industry.

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For more information write in No. 41

GT HOT LINE

PRINCE PHILIP QUOTES STATISTICS . . .

Duke of Edinburgh flew into New York City last month to open the British Exhibition. "Britain is not just an old country of tottering ruins where yokels quaff ale by the tankard outside rickety pubs," Prince Philip told his audience. "Remember, these same people started the Industrial Revolution . . . It is true, of course, that the plumbing in some of our older houses is not all that it might be – but that doesn't alter the fact that three out of every five gas turbines flying or on order in the entire Western World are British."

GE's LEVERETT NAMED ANS PRESIDENT . . .

Dr. Miles C. Leverett was named president of the American Nuclear Society for 1960-61. Pioneer in the atomic field, having worked with Dr. Enrico Fermi in 1942 when he built the world's first nuclear reactor under the University of Chicago's Stagg Field grandstands, Dr. Leverett is now Manager – Development Laboratories for General Electric Aircraft Nuclear Propulsion Department (ANPD) of Cincinnati, where he heads up GE's nuclear aircraft gas turbine development work.

BOEING GETS INTO HYDROFOILS WITH 110-TONNER . . .

Navy is leaning hard toward hydrofoils as possible solution to knotty problem of anti-submarine warfare. They've just awarded Boeing a $2,082,215 contract to build a 110-ton, 115-ft hydrofoil patrol craft. Reports are that Boeing successfully beat out bids from "most major aero-space-industry firms." Keel will be laid soon – at leased Martinac Shipbuilding Corp., Tacoma. Launch date: within two to three years. Power will be two 3000-hp turbines when out-of-the-water, 600-hp diesel in-the-water. Speeds near 100-knots are anticipated.

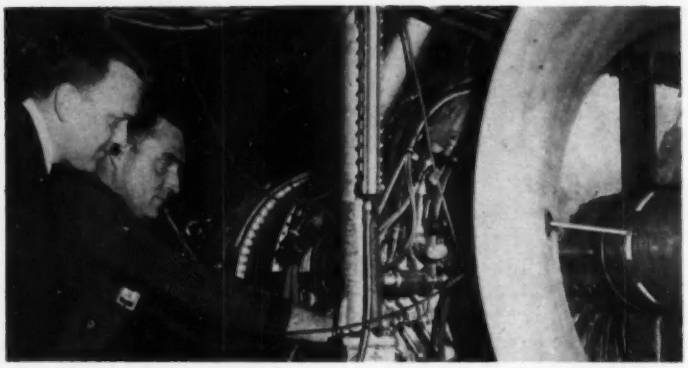
P&W's JT-3C RACKS UP COUPLE OF "FIRSTS" . . .

Two new "firsts" have been credited to Pratt & Whitney's JT-3C turbojet engine (it's the powerplant for the Boeing and Douglas jetliners). Federal Aviation Agency has extended American Airline and Trans-World Airlines 200-hr overhaul time to 1200-hr on the JT-3C engine. FAA's action marks first time that a US designed-and-manufactured pure jet engine has topped the 1000-hr standard for overhauls . . . and the first granting of a 200-hr increase in overhaul time. FAA also authorized extension of time-between-overhauls to 1000-hr for the P&W JT-4 engine on TWA jet airliners. JT-4, which powers intercontinental versions of Douglas and Boeing jet airliners was placed in commercial plane service a year later than the JT-3.

SOLID PROPELLANT ADVANTAGES DEMONSTRATED IN RECORD TURBINE RUN . . .

Garrett Corp's AiResearch Manufacturing Company is getting closer to practical use of solid propellants as auxiliary power source for missile-space-terrestrial applications. Their recent 32-min hot gas run on a 30-kva turbo-alternator proved that duration, once a bugaboo, is no longer a serious solid propellant limitation. AiResearch and Amoco Chemical Corp. have been working together on this problem for some time . . . appear to have come up with an answer that's competitive with liquid propellants. AiResearch plans to couple proven hardward and solii propellant gas generators with control devices that vary solid propellant burn-rates in accordance to varying load schedules. This will possibly include power generation equipment, actuators, reaction controls, pressurization systems and others.

GT INDUSTRY NEWS



Testing Jet for West Germany . . .
First of 66 GE J79-7, Mach 2 turbojets ordered by Lockheed for installation in West German F-104 "Super" Starfighters is checked after completing test-cell operation.

Trans-Canada's Turbo-Starters . . .
Boeing is busy building mobile ground support units—the Boeing Turbo-Starter, 502-11B—for Trans-Canada Air Lines. They've ordered 17. Picture shows Boeing's Industrial products assembly line.

Stowaway . . .
Portable AiResearch gas turbine starting cart is easily loaded. Used for starting this Rolls-Royce Conway-powered Douglas DC-8 during a functional-and-reliability demonstration flight for the Federal Aviation Agency, 8715-mile flight carried the jet to Latin American airfields where no jet starting equipment was available.

MORE INDUSTRY NEWS FOLLOWS ►

P&W's Indirect-Cycle Nuclear-Powered Aircraft Ready For Ground-Testing

Pratt & Whitney Aircraft division of United Aircraft Corporation is making "significant strides" in the development of an indirect-cycle system for a nuclear-powered manned aircraft, says the chief of the Aircraft Projects Branch of the Aircraft Nuclear Propulsion Office. The Aircraft Nuclear Propulsion Office coordinates the programs of the Atomic Energy Commission and the USAF.

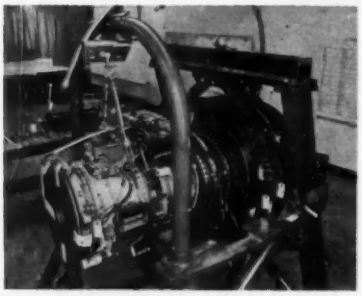
Colonel William A. Tesch, writing in the current edition of the *Air University Quarterly Review*, that research into the indirect-cycle system has progressed to the point where "our present plans at Pratt & Whitney Aircraft include the fabrication of an experimental ground-test reactor to prove out the basic materials and components."

In the indirect-cycle system, a nuclear reactor is remote from the turbojet engine powering the aircraft. A liquid-metal coolant carries nuclear heat from the reactor to a radiator in the turbojet, where the heat is exchanged to the air to produce thrust. This system says Colonel Tesch, "offers the potential for attractive performance in all applications, supersonic, subsonic."

World's First Turbine Fire Trucks

Two fire trucks, ordered from the American LaFrance Corporation of Elmira, New York, will be powered by a 325-hp gas turbine produced by the Boeing Industrial Products Division. Orders call for a new Seattle 100-ft aerial ladder truck and a 1,000 gallon - per - minute San Francisco pumper.

Formerly, these fire trucks were powered by reciprocating engines weighing up to 3,500-lb. Boeings 502 turbine weighs 325-lb or about 1% of the total truck weight. Turbine power will provide several important advantages: It will give the fire apparatus improved acceleration and hill climbing capabilities. Turbine fire trucks are expected to move through city traffic at a faster overall speed due to the improved acceleration.



GE's "Fan Burner" Promises 2000-mph Airliners

Whenever its needed, a new type jet engine, capable of powering military and commercial transport aircraft efficiently and reliably at speeds up to 2000-mph, can be produced. Testifying before a special investigating subcommittee of the House Science and Astronautics Committee, J. B. Montgomery, general manager of General Electric's Flight Propulsion Division, called the engine a "fan burner" and described it as one equipped to burn fuel in the exhaust of a fan mounted directly behind the basic jet engine. This type of aft-fan engine, Montgomery said, not only will best meet propulsion requirements for supersonic transport aircraft, but does not have to wait for new technology to be developed.

General Electric's first *small* aft turbofan engine, the CF700 is shown in the photo at the company's Small Aircraft Engine Department. This first release picture of the 4000-lb thrust aft fan powerplant shows it mounted in a thrust frame and equipped with instrumentation prior to entering the test cell. According to J. N. Krebs, manager of the CF700 project, operation was "highly satisfactory."

First Production J85-7 Shipped

First production contract shipment of J85-7 turbojets to McDonnell Aircraft for its GAM-72 decoy missile has been announced by General Electric's Small Aircraft Engine Department. Designed to be launched from a B-52, the "Green Quail" will be powered by a J85-7 when it enters operational service with the Strategic Air Command.

Highlights: American Helicopter Society's 1960 Annual Meeting

- A plaque was given to president Eisenhower by Ralph P. Alex, president of the Helicopter Society and assistant chief of component design at Sikorsky. Inscription on the plaque read: "Presented In Appreciation to Dwight D. Eisenhower, whose regular and extensive use of the helicopter has focused world attention upon—the most versatile vehicle yet devised by man."
- Exhibits contained many more gas turbines than piston engines. New helicopters are generally using turbines exclusively.
- A full scale static display of the GE twin-turbine powered 25-passenger Sikorsky S-61 transport helicopter was exhibited on the lawn in front of the Sheraton-Park Hotel, forum headquarters. General Electric displayed a T58 which had operated 2000-hr without overhaul. This T58-6 carries a military rating of 1050-hp and a fuel consumption of .64 lb/hp hr. It powers the Sikorsky HSS-2, Kaman HU2K and Vertol YHC-1A. The engine's FAA-certificated civil counterpart, the CT58-100, powers the Sikorsky S-61 and S-62 plus the Vertol 107 helicopter airliners. GE recently received an order from Vertol for $930,000 of CT58 Turbines.
- Continental gave a preview of their new Model 217-5A of 500 hp primarily designed for rotary wing application. The Model 217-6A is currently under development and is designed as a turbo prop, with 2100-rpm output. Both units have a separate power turbine.

Rolls-Royce Moves East-West

Rolls-Royce is currently working with MAN of Germany . . . as well as with Allison Division of GM in the US. RR is busy on jet engine development and local production with these two companies.

East German Auxiliary Turbine

The Pirna 017E, a single-shaft 130-hp unit with recuperator has operated 1200-hr at the Dresden factory. Its fuel consumption at full load is a little less than 1-lb/hp hr!

GT CONTRACTS PROCUREMENTS

Some major gas turbine procurements initiated and contracts awarded during recent months by various agencies of the U. S. Government are listed. This material is from the U. S. Department of Commerce publication "Synopsis of U. S. Government Proposed Procurement, Sales and Contract Awards."

• Dept. of the Navy, Bureau of Naval Weapons, Washington 25, D. C. "Conduct a product improvement program on the Model GTP 70 series gas turbine power unit. NOas 60-0163-c"—$49,755—The Garrett Corp., (AiResearch Mfg. Co. of Ariz. Div.) Phoenix, Ariz.

• AMC Aeronautical Systems Center, USAF, Wright-Patterson Air Force Base, Ohio. "T53-L-5 Shaft-Turbine Aircraft Engines; Data and Summary Bill of Materials. (Use: Army HU-1B Aircraft Program) (PR EP-0-2840-6598: MIPR R60-11-TCSMC-A and Amendment 1)"—$2,485,000—AVCO Corp., Lycoming Div., Stratford, Conn.

• San Antonio Air Material Area, USAF, Kelly Air Force Base, Tex. "Spare Parts 30 to 1840 ea. Items applicable to 4316-AE14A3 Governor Assy in support of J47-17B/33 Engine for F86D/K/L aircraft. (PR Sa.-O-FSG2915-E11219 & Amend. No. 1)"—$53,816—The Pierce Governor Company, Inc., Anderson, Ind.

• Oklahoma City Air Material Area, USAF, Tinker Air Force Base, Okla. "Reclamation of Parts and Disposal of J47-GE-25 Aircraft Engines. (RFP OC-0-02A-2300)"—Job—$355,690—Curtiss-Wright Corp., Utica Div., Utica, Mich. 2 bidders were solicited and 2 bids were received.

• Mobile Air Material Area, USAF, Brookley Air Force Base, Ala. "Spare Parts for MOAMA gas turbine overhaul program of various turbines AF 01(601)23514"—$259,444—Continental Aviation & Eng. Corp., Toledo 12, Ohio.

• Dept. of The Navy, Bureau of Naval Weapons, Washington 25, D. C. "Model J75-P-19W Engines, less Afterburners and Model J52-P-3 engines NOw-60-8219-i"—$45,845,-430—United Aircraft Corp., Pratt & Whitney Aircraft Div., E. Hartford, Conn.

• AMC Aeronautical Systems Center, USAF, Wright-Patterson Air Force Base, Ohio. "CY 1960 Product Improvement Engineering Services for the T56 Type Engine. (PR Ep-0-2840-6597; MIPR R60-2911-103)"—$1,800,000—General Motors Corp., Allison Div., Indianapolis 6, Ind.

• AMC Aeronautical Systems Center, USAF, Wright-Patterson Air Force Base, Ohio. "T53-L-3 Turbo-Prop Aircraft Engines, 126 each (For: Army AO-1 Aircraft Program); T53-L-1A Shaft-turbine Aircraft Engines (For: Army HU-1A Aircraft Program) and Data. (PR EP-0-2840-6599 (MIPR R60- 16-TCSMC-E and Amend 1)"—$11,131,675—AVCO Corp., Lycoming Div., Stratford, Conn.

• AMC Aeronautical Systems Center, USAF, Wright-Patterson Air Force Base, Ohio. "T58-GE-8 Turboshaft Engines, 204 each; Gear Box Assemblies, Engine Bulletins, Reading Paper Vandykes, Publications and Bill of Materials. For: HU2K-1 and HSS2 Helicopters, Dept. of Navy. (MIPR's R59-1978-114NOas, Amendments 1 and 2; R60-3924-NOas and Amendment 1)"—$5,500,000—"J58-GE-5 turbojet Engines, 143 each, and related Data. For: T38A Aircraft and GAM72 Program. (PR'S EP-0-2840-6375 and Amendment 1; EP-0-2840-6376)—$8,300,000—General Electric Co., Small Aircraft Engine Dept., West Lynn 3, Mass.

• Mobile Air Material Area, USAF, Brookley Air Force Base, Ala. "Spare parts for various types of airborne gas turbine compressors PD (01-601) 60-2 to AF (01-601) 28529"—6056 ea—$282,392—Solar Aircraft Co., San Diego 12, Calif.

• AMC Aeronautical Systems Center, USAF, Wright-Patterson Air Force Base, Ohio. "T56-A-7 Turbo-prop Engines, 83 each (2 each for Air Training Command; 2 each for Spare Support of SC-130B Aircraft, Coast Guard; 16 each for Installation, and 9 each for Spare Support for C-130B Aircraft—Navy; 28 each for Installation, and 26 each for Spare Support for GV-1 Aircraft—USMC); T56-A-8 Turbo-prop Engines, 12 each for Installation in W2F-1 Aircraft—Navy; T56-A-10W Turbo-prop Engines, 34 each (17 each for Installation and 16 each for Spare Support of the P3V-1 Aircraft, and 1 each for training—Navy); and Related Changes. (MIPR's R60-3926-35-NOas; R60-3923-27-NOas; R60-3624-32-NOas; PR's EP-0-2840-6186; EP-0-2840-6409; EP-0-2840-6410)"—$11,610,000—General Motors Corp., Allison Div., Indianapolis 6, Ind.

• AMC Aeronautical Systems Center, USAF, Wright-Patterson Air Force Base, Ohio. "J69-T-29 Turbo-Jet Engines iaw/Contractor's Specification 2157A as revised 20 January 1959 and Installation Drawing 576776, 108 each. Use: Installation and Spares for Ryan Q2C Target Drone. (PR's EP-0-2840-6134, Amendment 1; EP-0-2840-6547)"—$1,576,800—Continental Aviation and Engineering Corporation, Detroit, Mich.

Company-Reported Contracts

• Solar Aircraft Company reports receipt of an order for five additional airborne Titan turbopump APU's for the Army's new YHC-1B transport helicopter. This "Chinook" helicopter is produced by Vertol Division of Boeing Airplane Co. The Titan engine will drive a hydraulic pump to start helicopter's main gas turbine engines, run accessory drives and utility systems.

• Solar Aircraft Company also reports a $2-million order from the Air Force for additional gas turbine-driven APU's for the KC-135 jet tanker. Solar's Mars turbine APU's on the KC-135 provide electrical power for a variety of equipment and have heat exchangers to use exhaust heat for cabin heating. This jet tanker, produced by Boeing Airplane Company, is the fifth major aircraft to use Solar's Mars auxiliary power unit.

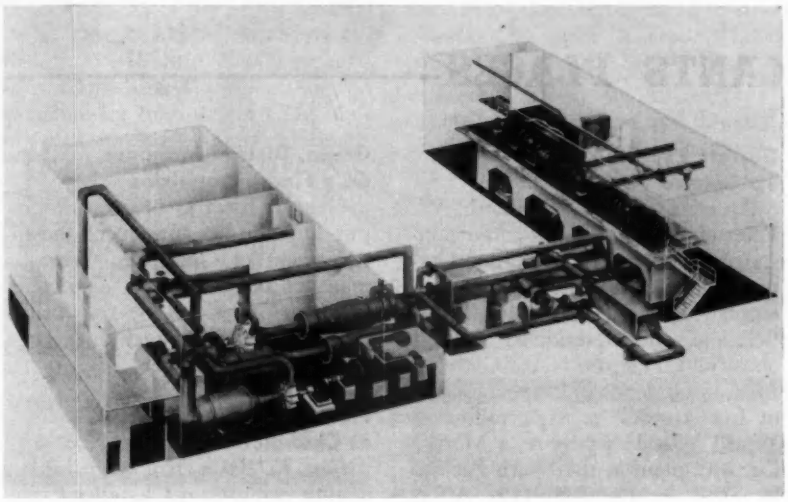
• General Electric's Large Jet Engine Department reports contracts valued at nearly $10-million for product improvement of its J79 turbojet engines for the U. S. Navy. Let by the Air Materiel Command's Aeronautical Systems Center, the contracts cover present and future powerplants for the Navy's McDonnell F4H-1 fighter and North American Aviation A3J bomber.

• General Electric's Large Jet Engine Department has also announced receipt of contracts for its J79 Mach 2 turbo-jet engines. Let by the Air Materiel Command's Aeronautical Systems Center, awards totaling more than $56-million are for engines to be used in Navy's McDonnell F4H-1 fighters and North American Aviation A3J bombers as well as Air Force Convair B-58 bombers.

An additional $4-million is represented by J79 orders slated for use in Lockheed's F-104 Starfighters for the Federal Republic of Germany.

• The Garrett Corporation's Phoenix Division reports that over 400 air turbine motors, auxiliary power units, are on order or delivered for the Air Forces Republic F-105 fighter-bomber.

• Over 400 air turbine motors, auxiliary power units, are on order or delivered for the Air Force F-105, according to The Garrett Corporation's Phoenix division.



Independent Test Laboratory Now At Your Service!

An independent gas dynamics test laboratory for experimental and development testing is now available. Technology is moving rapidly today and test facilities, including instrumentation, are becoming more complex and sophisticated—as well as more expensive. Therefore, it's important news for the gas turbine industry that an independent, complete and specialized laboratory is now in being.

Advance Propulsion Division, Aerotest Laboratories, Inc., built the laboratory. It may be used on an exclusive facility rights priority basis for complete research, test and evaluation programs. It was designed to test turbo machinery, air-breathing and non-airbreathing power plants, reciprocating engines and combustion chambers. It is also equipped for extensive aerodynamic evaluations and model testing.

Laboratories consist of a main compressor plant capable of developing up to 504,000-lb of supply air-per-hr or 12,000-lb per-hr up to 250-psig; four test cells and a separate research building.

Test cells break down into an altitude chamber, single-stage compressor stand, turbine test stand and a multi-stage compressor stage and combustion chamber stand. Each has a wide range of capabilities in its specialty. A complete rundown on test facilities can be obtained from the gas dynamics Division of Aerotest.

World's Largest Vacuum Furnace . . .

Allegheny Ludlum Steel Corporation will build the world's largest vacuum-melting furnace at its Watervliet Works in New York State, Clark W. King, executive vice president, announced. Alloys melted by the consumable-electrode vacuum process are being specified in critical areas, as for example, in powerful lightweight jet turbines, such as GE's new J-85 lightweight turbojet engine.

This special furnace of a type pioneered by Allegheny Ludlum and its affiliate, Titanium Metals Corporation of America, will produce ingots up to 50-in. diameter and at least twice the weight of any vacuum-melted ingots now being produced commercially. The largest such steel ingots available today weigh less than 20,000 pounds; the new Allegheny Ludlum furnace will be able to produce ingots of at least twice this size. Commercial development of the consumable-electrode vacuum-melting furnace began in 1948, when Allegheny Ludlum began research work on titanium. Some time later, the process was adapted to the melting of zirconium, high-temperature - resistant stainless steels, super-alloys and other alloys.

GT "COMING UP" REMINDER

AUGUST 15-17 American Society of Mechanical Engineers and American Institute of Chemical Engineers Heat and Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, New York.

AUGUST 15-20 International Aeronautical Congress, The Royal Institute of Technology (Kungl. Tekniska Hogskolan), Stockholm, Sweden. Address: IAF-60, Box 5045, Stockholm 5, Sweden.

AUGUST 16-19 Society of Automotive Engineers, National West Coast Meeting, Jack Tar Hotel, San Francisco, California.

SEPTEMBER 12-15 Society of Automotive Engineers, National Farm, Construction, and Industrial Machinery Meeting, Milwaukee Auditorium, Milwaukee, Wisconsin.

SEPTEMBER 12-16 Institute of the Aeronautical Sciences, 2nd International Council of the Aeronautical Sciences, Zurich, Switzerland.

SEPTEMBER 21-23 American Society of Mechanical Engineers-American Institute of Electrical Engineers, Power Conference, Philadelphia, Pennsylvania.

SEPTEMBER 26-28 American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans, La.

SEPTEMBER 27-30 American Rocket Society, Power Systems Conference, Miramar Hotel, Santa Monica, California.

SEPTEMBER 25-28 American Institute of Chemical Engineers, Mayo Hotel, Tulsa, Oklahoma.

OCTOBER 2-5 American Institute of Mining, Metallurgical and Petroleum Engineers, Society of Petroleum Engineers, Fall Meeting, Denver, Colo.

OCTOBER 3-5 Institute of the Aeronautical Sciences, Midwestern Meeting on Air Logistics, Tulsa, Oklahoma.

OCTOBER 10-14 Society of Automotive Engineers, National Aeronautic Meeting (including a manufacturing forum and engineering display), The Ambassador Hotel, Los Angeles, California.

OCTOBER 17-18 Institute of the Aeronautical Sciences, CAI/IAS Joint Meeting, Queen Elizabeth Hotel, Montreal, Canada.

OCTOBER 20-22 Acoustical Society of America, San Francisco, Calif.

OCTOBER 25-27 Society of Automotive Engineers, National Transportation Meeting, Hotel Leamington, Minneapolis, Minnesota.

OCTOBER 31-NOVEMBER 2 Society of Automotive Engineers, National Power Plant Meeting, Hotel Cleveland, Cleveland, Ohio.

GT PEOPLE PLANTS PLACES

Western Gear Teams-Up With Teddington Aircraft

An international industrial alliance of significance between **Precision Products Division of Western Gear Corporation,** Lynwood, California, and **Teddington Aircraft Controls,** Ltd., of Middlesex, England, will result in Western Gear assuming sales, service and manufacturing of Teddington designs and products for missile, rocket and aircraft systems. Principals involved are shown above as they finalized exchange plans. From left to right are **John Griffiths,** a director of Teddington in charge of sales; **Rex Saunders,** Teddington's resident engineer at Washington, D. C., and **Thomas F. Bannan,** president of Western Gear Corporation. Teddington controls are extensively applied on aircraft jet engines, including Rolls Royce Conway power plants on DC-8's and Boeing 707's.

Clyne Moves To Sikorsky

James W. Clyne, a top sales executive with **Douglas Aircraft Company** and at 47, a veteran of 25-years in aviation, has been named to the newly-created position of manager of sales and service of **Sikorsky Aircraft Division of United Aircraft Corporation. Lee S. Johnson,** Sikorsky general manager, said "The addition to the division's managerial staff is being made to meet growing sales and service demands associated with the introduction of a number of new helicopter models, all turbine powered."

Bettinger Sitting Pretty With $4-Million Backlog!

Bettinger Corporation, processor and fabricator of ceramic-on-metal products, has increased its order backlog to an all-time high of over $4-million. "Second half of 1960 should be the biggest half-year in the company's history, both as to sales and profits," said **Robert A. Weaver, Jr.,** Bettinger president.

Garrett Expert To Geneva Post

Appointment of **Bernard W. Peterson** as resident gas turbine installation engineer for **Garrett Corporation,** Geneva, Switzerland, has recently been announced by E. A. Bellande, vice president, foreign operations. Peterson joined Garrett's AiResearch Manufacturing Division in Los Angeles in 1946, following World War II service as a Marine Corps Captain in the South Pacific. In 1951 he transferred to AiResearch in Phoenix as an expert in small gas turbines. His new post will see him serving as advisor on AiResearch turbines for British, French and German airframe applications.

Chandler-Evans Changes

William B. Gurney has been appointed engineering manager of **Chandler Evans Corp.,** and **Jack O. Nash** has been named chief engineer of the company.

Gurney has been manager of Chandler Evans' west coast engineering and sales office in Hollywood, California, since he joined the company in 1956.

Nash joined Chandler Evans as a project engineer in 1950. He was appointed assistant chief engineer in 1956 and since that time has supervised the company's advanced engineer and component development program.

New Hydrofoil Company Formed

The Hydrofoil Corporation of America, is the name of a brand new outfit building commercial and pleasure hydrofoil-equipped boats. **A. C. Amantea,** President, announced that **John Bader** and **Vordaman Van Bibber,** who have formed the corporation, have over 25-yr experience with major boat and ship building companies and the Bureau of Ships, U.S.N. Their first boat will be a 29-ft. hydrofoil.

Grega, District Manager GE's Flight Propulsion

General Electric's Flight Propulsion Division has announced the appointment of **George E. Grega** as manager of its central district in Dayton. Grega will be responsible for FPD products including large and small jet engines.

New Quality Manager at Chandler Evans

Carl F. Baker has been named quality manager at **Chandler Evans Corp.,** West Hartford, Conn., after serving in this same capacity and additionally for ten years as chief engineer of the Hamilton Standard division of United Aircraft Corp. He will be in charge of all quality control and inspection activities and will supervise liaison between the engineering and manufacturing departments of the company. He will also be responsible for product value analysis.

Stokke To Manager Garrett's Detroit Office

Allen R. Stokke has moved up to manager of Garrett's sales office in Detroit, Michigan. **W. J. Pattison,** vice president in charge of sales for **Garrett Corporation,** Los Angeles, announced the appointment.

GE Personnal Changes At Lynn

Appointment of **Martin C. Hemsworth** as manager of engineering and **Edmund Van Claxton** as T58 engine project manager at GE's Small Aircraft Engine Department has been announced by **Gerhard Neumann,** department general manager. Hemsworth will be responsible for engineering activity associated with development, testing and production of the T58 turboshaft, J85 turbojet, CF700 turbofan and T64 turboshaft/turboprop aircraft gas turbines. Claxton will be responsible for the design, development, qualification, manufacture and sale of the T58 and CT58 turboshaft engines and Model 720 industrial gas turbine.

Manager for New Clark Bros. Dallas District Office

William A. Roever has been named manager of the newly created Dallas District Office, according to **George W. Probst**, Vice-President-Sales, **Clark Bros. Co.** He will be responsible for the sales of Clark engines, compressors and gas turbines in the central part of Texas and the lower half of New Mexico, operating from the new office located at 4512 North Central Expressway, Dallas 6, Texas.

Mr. Roever has been with the Clark organization since 1946 as Sales Engineer, Dallas Branch Manager and most recently, Senior Branch Manager.

Millward T. Thomas

Millward T. Thomas, 1875-1960

The recent death of **Millward T. Thomas**, founder and President of the **Thomas Flexible Coupling Co.**, has been announced.

Mr. Thomas, responsible for the invention and development of the Flexible Power Transmission Coupling, led his company to its present position as the recognized leader in the field.

Richard H. Crook, who has served as a director and personal advisor to Mr. Thomas, has been elected as successor to the late president.

GE Turbine Expert Assigned To Airlines

General Electric has announced the appointment of **Donald L. Rohrkemper** as Commercial Engine Representative. He'll assist **TWA, Delta** and **American Air Lines** in the operation, service and overhaul of their G-E jet engines at O'Hare International Airport. O'Hare is the key "turnaround" where major airlines perform scheduled engine maintenance.

Recent Moves At Solar

Creation of a new marketing division headed by **Lynn D. Richardson**, vice president-sales, was announced by **Solar Aircraft Company.**

• **Fred S. Hage, Jr.**, formerly assistant to the president and director of marketing. Hage will supervise the activities of the marketing division, including sales, contract administration, advertising, sales promotion and market planning and research.

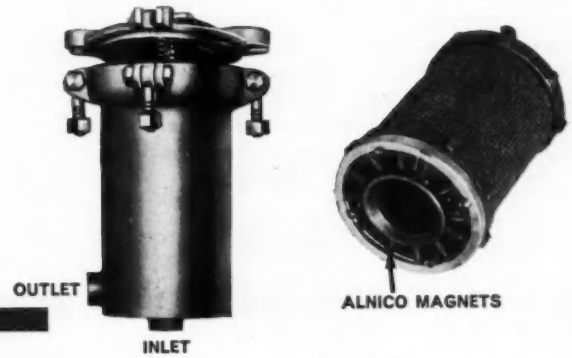
• **R. Sherman Platt**, secretary of the company, has assumed responsibility for corporate public relations.

• **Jack L. Duke** has been named sales representative for Solar's gas turbine engines and turbomachinery products in Houston, Texas, and the gulf coast area.

Zimmerman To Sales Manager At Fairchild Engine

Stratos Division of **Fairchild Engine and Airplane Corporation** has appointed **James J. Zimmerman** as Sales Manager, Industrial Turbo Machinery.

GET THE *ADDED PROTECTION* OF MAGNETIC SEPARATION WITH THIS BASKET-TYPE STRAINER



Nugent now manufactures a line of basket-type strainers offering the added protection of magnetic separation. Specially designed Alnico magnets establish a magnetic field through which the strained liquid must pass as a final stage before leaving the unit. Thus, minute ferrous particles are trapped and removed from the fluid stream.

If you have valuable engines or other equipment which demands top-notch lubrication protection, it will pay you to get the full story on the Nugent combination strainer-magnetic separator.

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For more information write in No. 42

A round-up of GT

SERVICE EXPERIENCE and MAINTENANCE

How good is gas turbine reliability? Is it improving? What troubles are experienced? What is the pattern of maintenance . . . inspection? These questions are answered in this roundup showing results of almost 5-million hours of gas turbine operation! Maintenance experience in aircraft propulsion, gas pipeline pumping, power generation by utilities, auxiliary power and marine use is covered.

All phases of the subject were discussed at the Aviation Conference, ASME, in Dallas, Texas, June 5-9, 1960 and this roundup is based on data presented there. A full bibliography of the papers presented is given at the end of this article for those wishing to pursue the subject further.

GAS TURBINES DISCUSSED AT DALLAS CONFERENCE

Operator — Service	Engines	No. in Service	Operating Hours
Aircraft Propulsion			
American Airlines, Inc.	JT3C-6[1]	96	250,000
British Overseas Airways Corp.	Avon Mk 524[2]	76	250,000
British Overseas Airways Corp.	Proteus[3]	128	1,000,000
British European Airways	Dart[3]	252	2,100,000
US Air Force	J-79[4]	300	100,000
Totals		852	3,700,000
Industrial — Marine — Auxiliary			
El Paso Natural Gas Company	—[4]	32	1,000,000
Oklahoma Gas & Electric Co.	—[4]	2	59,000
Various Operators	502[5]	808	196,000
Totals		842	1,255,000
Grand Total		1694	4,955,000

Footnotes
1—Pratt & Whitney 3—Bristol Siddeley Engines, Ltd. 5—Boeing
2—Rolls Royce, Ltd. 4—General Electric

How American Airlines maintains its turbo-jet engines . . .

AMERICAN is conducting all inspections and performing complete overhauls on the JT3C-6 turbo-jet engines in their aircraft. This engine has been in service for about a year. It's reliability record is excellent. The 1959 unscheduled removal rate of 0.38 engines/1000 engine operating hours is the lowest that American Airlines has experienced with a new engine.

In 1959 there were only 18 incidents involving in-flight shutdown of engines. Five of these were due to engine or engine accessory malfunction. In this period there were some 56 unscheduled engine removals, 17 of which were caused by failure or malfunction of the engine or engine component. Other removals were of a convenience nature resulting from conditions that could lead to more serious trouble.

At engine overhaul a continual program of detailed evaluation of all components is conducted. Information is accumulated on 137 parts that are serialized in each engine. Each of these parts in each JT3C-6 engine has an individual card, updated at each overhaul to show total operating time on the part, total time the part has operated in any engine of which it is a part, repair history, and other data. The 1135 compressor blades and 293 turbine buckets in each engine are time-coded at each overhaul so each blade or bucket carries its own record of total accumulated time actually in service.

Observations of parts during engine overhaul show the following:

a—Main engine bearings generally perform well. Only area of moderate distress is the compressor rear bearing, a duplex ball bearing. These bearings appear to have 4000 to 5000-hr airline service life.

b—Compressor blades show generally good condition with no signs of fatigue. Initially, seal and tip-rubbing called for minor blade repair. New clearances eliminated this problem.

c—Compressor stators show some small evidence of cracking in the low-pressure compressor or looseness in high-pressure stages. The former is repairable and the latter has been accepted for continued service.

d—Diffuser section and all engine cases in general require minimum amount of overhaul attention. Small cracks in diffuser case and exhaust struts are repaired by welding.

e—Combustor sections are doing well. Burner cans operate for two overhaul periods and then a new head is installed.

f—Turbine sections have been trouble free. There is reason to believe that 2nd and 3rd-stage turbines will perform adequately for over 5000 hours.

BOAC's maintenance experience with Rolls-Royce jets . . .

BOAC USES the Rolls Royce Avon Mark 524 in its Comet-4 Jets. Total engine-hours accumulated on the Avon family of turbines is 2,922,000. Military service shows 2,614,000 hours with civil and transport (including RAF Transport Command) 308,000 hours.

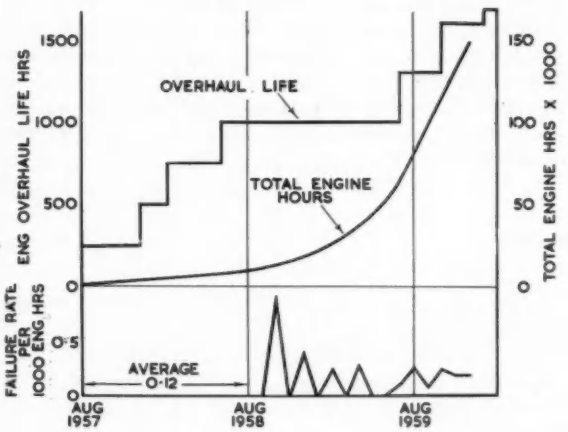
Routine maintenance of engine and installation throughout its service life, including thrust reverser and jet pipe, is almost entirely confined to visual checking for oil, fuel or gas leaks, security of components, filter checks and routine functioning. Maintenance check patterns in BOAC, as far as the engine is concerned, is broken down into: transit check as necessary; base check every 100 hr; check I every 200 hr; check II every 400 hr, check III every 2000 hr.

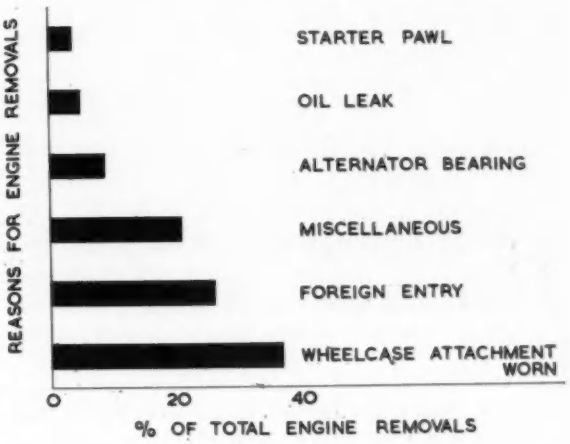
Overhaul facilities have been established by BOAC and work is just commencing. Overhaul life averaged out at about 675-hr per year over the period August, 1957 to December, 1959. Overhaul life growth rate from 1957 into 1959 is shown. Engine removal and causes are also illustrated.

Note that wheelcase attachment is the prime cause. This trouble centered around a spherical bearing-type attachment which fretted badly under operating conditions, allowing the wheel case to settle and start oil leaks. Foreign entry damage is the No. 2 cause of engine removals. Inspection of inlet guide vanes and compressor's first stage (accomplished by crawling down the air intake) is all that's necessary to determine engine condition.

Damage beyond this point indicates engine removal since the degree of damage usually precluded correction by the permitted limited amount of blending.

Based on experience to date, an ultimate of 3000-hr overhaul interval is considered reasonable. Anticipated buildup of engine flying hours on all Avons could exceed 3-million by the end of 1960.



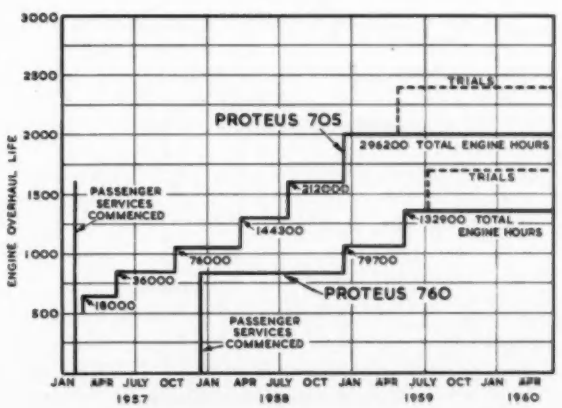


Maintaining the Bristol Proteus in Britannia aircraft . . .

BOAC USES the Bristol Proteus in its Britannia Aircraft. Total operating time on all Proteus engines in civil operations is about one-million flight hours. Of this, BOAC's total on the Proteus 705 is over 475,000-hr and about 350,000 on the Proteus 760. Overhaul rate on these two engines is shown. The 705 overhaul life increases about 750 hours a year. The 705 overhaul is now 2000 hours with current trials to 2400 hours. The 760-series trials are now in progress for 1700 hours.

Turbine blade failures occurred in a number of engines during the latter part of 1959. Replacement of blades with material of better creep properties has taken place.

Additional blade trouble, particularly on the 705 turbine, has not been entirely due to creep. A condition, known as "black plague", shows as a rough scaly blackened area in which blade cross-sectional area is reduced. It is located in middle third of blade length and leads to inevitable fracture. Sulfur in some form is basically responsible. A catalyst is believed necessary to start the attack. A blade material of increased chromium is being tried and also a blade with the surface area pack aluminized.



BEA and propeller-turbine engines . . .

COMPARED WITH PISTON-ENGINE EXPERIENCE, the Rolls Royce Dart propeller-turbine engine in BEA service over the years has proved to be of superior reliability with greater overhaul life potential. Present overhaul life is far in advance of any known piston engine and the Dart is much easier to maintain.

H-P turbine-blade failures resulted in a large number of Dart engine premature removals. These were Nimonic 80S blades that failed in creep. Causes were related to: inferior creep properties of certain materials batches; pyrometry errors; and increased flame temperatures resulting from operation under constant JPT limits and use of mechanically-improved flame tubes. Trouble was eliminated by a life limit of 3000-hr on H-P turbine blades, weeding out inferior blade batches and revising JPT operating limits. Nimonic 105 blades with improved resistance to creep and thermal shock are now being tried.

H-P turbine air seal failures resulted in two cases of secondary damage and disk failure from overheating. This seal, of centri-cast material, failed by fatigue cracking. A forged alloy-steel seal eliminated this defect.

Overhaul life of the Dart engines is: Mks 506-510-2400 hr; and Mk. 520-1900 hr. Rate of increase in overhaul life is illustrated. One example of improvement in component life was in flame tubes. An early design tube failed after only 500-hr running time. New design tubes have considerable life after 2100 hours.

Some 54 life-development trials and 19 trials on modified or salvaged components have been conducted in efforts toward safer and more economic operation. At this time, BEA has in progress eight trials on repair schemes, eight on overhaul life development and 13 on modified components.

Air Force maintenance on GE's J79 engines . . .

VIBRATION WAS ENCOUNTERED with the engine early in the program. Its causes included the following:

a—Unbalanced rotor, resulting from circumferential shifting of glanges, axial shifting of rotor blades, and high axial compressor-blade loads.

b—17th-stage seal failure from poor bonding of heavy silver plating.

c—Foreign object damage resulting in partial blade loss and displacement.

Modifications to overcome the vibration include:

a—Controlling maximum allowable spacer runout.

b—Limiting initial rotor assembly unbalance to 100 gram-in.

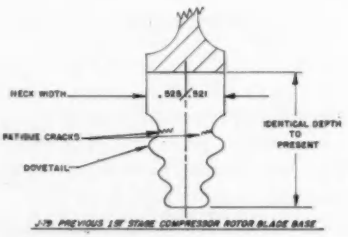
c—Increasing compressor-rotor bolt capacity.

d—Increasing radial fits on rotor disk rabbet diameters.

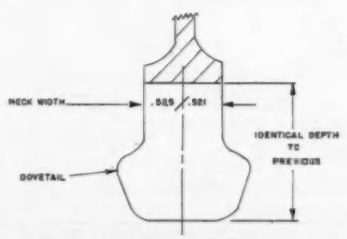
e—Beef-up of rotor spacer's flanges to minimize flange-bending moments.

f—Elimination of aluminum-silicone paint on flange surfaces.

g—Incorporation of a silver-plated steel band in the 17th-stage seal, thereby eliminating requirements for heavy silver plating.



J-79 PREVIOUS 1ST STAGE COMPRESSOR ROTOR BLADE BASE



J-79 PRESENT 1ST STAGE COMPRESSOR ROTOR BLADE BASE

Modifications were minor in nature and have stopped the excessive vibration initially encountered. Maximum vibration limits now set by USAF for this engine permit a 4.5-mil double-amplitude displacement for post-overhaul testing and a 6-mil double-amplitude displacement for field use at military power, with a constant G loading curve at all other engine speeds down to idle.

Redesign of compressor rotor-blade dovetail from a multi-tang to a single-tang design (shown) was necessary to eliminate fatigue cracking. Flight tests indicated overall peak stresses on the average of 27,000 psida (psi double amplitude) which in some cases exceeded maximum structural design limitations of the blade. Redesign solved this problem.

Maintaining pipeline gas turbines . . .

EL PASO NATURAL GAS COMPANY has, since 1952, installed 32 gas turbines, normal rating 5750 hp, as intermediate boosters on its main transmission lines. As of December, 1959, more than 1,000,000-hr operation had been accumulated on these turbines.

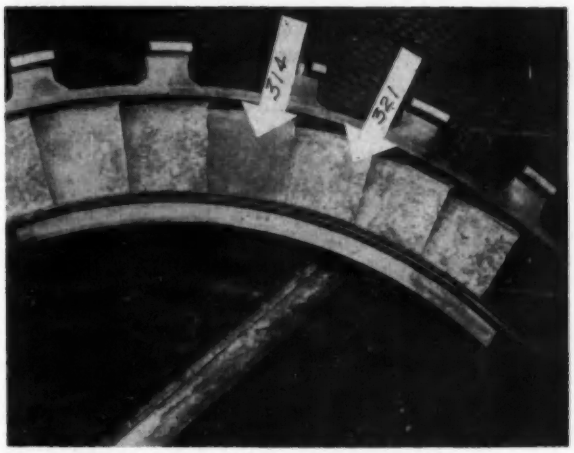
Compressors are cleaned twice each year. Steam cleaning can be done in four hours. Injection of granular compounds into the air inlet can be done during periods of high load factor but is not as satisfactory as the manual method.

Combustion systems have developed no serious problems. Experience points to the desirability of inspecting components at 7000 hours. The combustion system seems capable of operating 20,000 hours before replacement.

In first-stage nozzles, thermal fatigue cracks starting at the trailing edge and progressing axially toward the leading edge were encountered on type 321 material between 6000 and 20,000 hours. Nozzles of 314 material have given excellent service. One set of 314 nozzles were found free from cracks or oxidation pitting after 45,000-hr service. The higher chromium and silicon content of the 314 material is responsible for its improved properties. Difference between 321 and 314 nozzles, after 13,000 hr, is shown.

First-stage turbine buckets of three materials, Nimonic 80A, S816 and M252, have been tried. S816 buckets have given excellent service, one set has over 43,000-hr operation. Two sets of M252 buckets have 15,000-hr. Nimonic 80A failures were found after 15,000 to 19,000 hours. They were from bar stock rather than forgings. Double-aged heat-treated Nimonic 80A buckets appear to have better rupture life than S816. One set of Nimonic 80A buckets now has over 30,000-hr service.

Hook cracks developed on both sides of the first-stage turbine wheel after 8000-10,000 hours. Various fixes have been tried, including 10th-stage air extraction (from 300 to 120°F) and introduction of this cool air into the wheel-space region closer to the dovetail section. If this cooling modification does not prevent further cracking, the wheels may require rerimming and long-shank buckets.



Condition of Type 314 and Type 321 material after 13,000-hr of operation.

Utility's maintenance of natural gas-burning gas turbines . . .

TWO GAS TURBINE-DRIVEN GENERATOR SETS of Oklahoma Gas & Electric Company have accumulated 59,000 hours in power generation service (as of May, 1960). Pertinent operating data for both sets is given:

	Unit No 3	*Unit No. 4*
Installed	July, 1949	July, 1952
Capacity, kw	4300	4400
Total installed hours	91,380	65,265
Total operating hours	38,294	19,829
Total non-operating hours	53,086	45,436
Total forced-outage, hr	394	177
Total scheduled outage, hr	6,626	3,037
Total hours available but not operating	46,066	42,222
Average thermal efficiency, %	16.8	18.1
Total number of starts	1077	1103
Reliability factor, %	99.0	99.1

Forced outages on the two generator sets were:

No. 3—A total of six for a downtime of 394 hr.
No. 4—A total of five for a downtime of 177 hr.

Outages were not due to failure in compressors, combustors or turbines. They were all due to accessories associated with the complete generator package.

Total maintenance cost, labor and material for both plants averaged $1.44/kw capacity/yr. Man-hours of labor spent in maintenance averaged 0.27/kw capacity/yr.

Until first cost of gas turbines are reduced, they cannot be justified for prime generation in evaluation against steam units. Current steam plants are costing $100/kw for high-grade reheat cycles and are producing energy for 9600 Btu/kw/hr.

Maintenance experience with smaller Boeing gas turbines . . .

THIS MAINTENANCE EXPERIENCE with Boeing 502 gas turbines, rated from 150-360 hp, is based on more than 800 engines with an accumulated service time in excess of 196,800 hours. Over 97,000 hours were on compressor engines with some 99,000 hours on shaft engines.

Preventative maintenance inspections include:

1—*Daily* Visual check of the engine, including oil and fuel level.

2—*Burner* Remove, disassemble and inspect components, follow by an operational check run.

3—*Hot Section* Disassemble gas producer for dye-penetrant inspection of turbine wheels, nozzle box and nozzle ring. Follow by operational check run.

4—*Overhaul* Completely disassemble engine, clean, inspect and repair as needed. Follow by fully-instrumented performance test run.

Frequency of inspection and overhaul may vary with application. The 502-10C turbine in Navy service gets burner inspection at 100 hours, hot section at 300 hours and overhaul at 900 hours.

Trouble areas encountered during the 502 turbines' operations are:

1—*Burner Dome* Excessive cracking between air slots. A modified dome with round rather than slotted holes has shown greater life.

2—*First-stage turbine wheel* Blade weld cracks accounted for replacements in three out of 32 engines. Fir tree-type attachments have replaced welding.

3—*Nozzle box and ring* Cracks in these parts could usually be repaired by welding.

4—*Air-flow controller* On Turbostarters, this part gave considerable trouble by failure to hold adjustment, resulting in low output air pressure. A fix included increasing corrosion resistance of a poppet valve and changing the taper of a needle valve for less sensitive adjustment.

Finally, evaluation of plastics as a compressor housing material . . .

GLASS-REINFORCED PLASTICS as an aviation gas-turbine compressor housing material is being investigated in an effort to eliminate magnesium which presents serious corrosion problems in salt atmospheres. The plastic was tested as a compressor housing material on a standard Westinghouse J34-WE-36 gas turbine. A polyester resin was selected after test.

A complete compressor housing was fitted with stator-vane assemblies and tested. The major part of testing was conducted in accordance with MIL-E-5009A:

a—Start and run at 4000 rpm for 3 min.

b—Accelerate to 12,500 rpm in 500 rpm steps holding 1 min at each step.

c—Decelerate to 4000 rpm in steps, holding 1 min at each step.

d—Shut down and listen for rubs.

e—Start engine; hold at 4000 rpm for 3 min; then jam-accelerate to 12,500 rpm in 10 to 12 sec.

f—Hold at 12,500 rpm for 3 min.

g—Shut down and listen for rubs.

h—Proceed with 150-hr endurance run per specification MIL-E-5009A.

i—After 5 (±1) hours, shut down and check torques.

j—After 50 (±5) hours, shut down, remove cover half of housing and inspect. If satisfactory replace and resume testing.

After 5-hr operation there was no relaxation of bolt torque. At 50 hours there were no indications of tip rubs, erosion or deterioration due to heat. Housing was in excellent condition and was therefore reassembled and run for the remainder of the 150-hr endurance test without further inspection.

In the 200 hours of operation, only sign of wear was a slight amount of erosion in a resin-rich area at the leading edge of an outlet vane slot. Feasibility of compressor housings of glass-reinforced plastic has been proven for engines with a 4:1 compression ratio.

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GTUA

grows in size and accomplishment

How the Gas Turbine Users Association started, where it stands and what it's doing. This constructive user group can help the whole industrial gas turbine industry.

by A. H. Carameros, Supervisory Engineer
El Paso Natural Gas Co., El Paso, Texas

Late 1955 saw application of gas turbines growing at a rapid rate. Being a relatively new machine to US industry, experience was very limited and somewhat scattered. Older users found themselves answering the same questions over and over again, so it was proposed that all users get together once a year and review all experience to date.

First meeting was held on May 7, 1956, in El Paso, Texas and was sponsored by El Paso Natural Gas Company. It lasted two days and was attended by representatives from Northern Natural Gas Company, Southern Counties Gas Company of California, Tennessee Gas Transmission Company, Texas Eastern Transmission Company, Truckline Gas Company, and United Gas Pipeline Company.

The first meeting set a pattern for those following. It was decided to have a rather informal program—a sort of a round-table discussion. Each company was given time to review its experiences during the year. During discussion, questions were asked and if possible answered by anyone at the meeting. Notes were taken freely by all concerned but no formal report was prepared. The meeting proved very informative and it was decided to get together once a year.

Later it was decided that each year a different company would sponsor the meeting and rotate until everyone had a chance at sponsorship. In 1957, sponsor was Southern Counties Gas Company of California and the meeting held in Palm Springs, California; in 1958 by Texas Eastern Transmission Corporation in Shreveport, Louisiana; in 1959 by Tennessee Gas Transmission Company in Houston, Texas; in 1960 by Northern Natural Gas Company in Omaha, Nebraska.

Chairmanship of the group was automatically given to the person representing the sponsor for the coming year.

The group has now grown and has members from:

Trans-Arabian Pipeline Company
Petro-Chemicals, Incorporated
Union Carbide Chemical Company
Asiatic Petroleum Corporation
American Cyanamid Company
Creole Petroleum Company
Esso Standard Oil Company
Arabian American Oil Company
City of Monroe Louisiana
Union Pacific Railroad
Humble Oil & Refining Company

One obvious missing link in the group is the manufacturer. It was decided early in organization that only users could attain membership. That is, if a company owned and/or operated one or more gas turbines of any make they could become a member. Main reason for this exclusion was that all members felt they would speak their minds more freely if the manufacturer was not there to contest each statement. However, it was obvious that all concerned would benefit considerably by making manufacturers aware of what went on at these meetings.

It was then decided that a committee, representing the group would be organized to meet with each manufacturer. In October, 1958, the first Gas Turbine Operation Committee representing the association met with management of Clark Brothers, General Electric and Westinghouse to attain objectives we set forth as follows:

1. Create a better understanding between management of gas turbine manufacturers and users.

2. To keep users informed on what progress has been made on new units and how these developments could be made applicable to existing machines.

3. To plan (both manufacturer and user) for adequate spare parts to guarantee uninterrupted operations and/or keep down time to a minimum.

4. To keep all interested users informed of current troubles in the gas turbine field, whether applicable to the users' units or not.

5. Discuss feasibility of standardization.

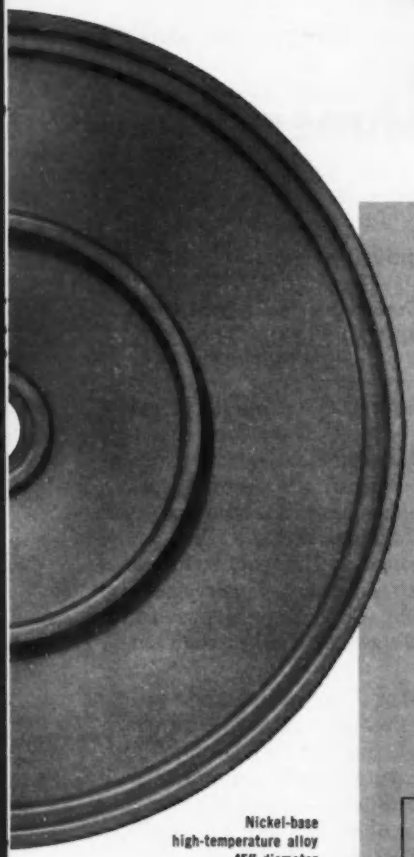
These meetings proved of tremendous value to both user and manufacturer. Another tour was completed in January, 1960, by the Committee during which it met a wonderful spirit of cooperation on the part of manufacturers.

Another round-table discussion was held in Omaha, Nebraska April 27-28, 1960, and sponsored by Northern Natural Gas Company.

So, through cooperation of all members, the group has increased its knowledge of application and operation of gas turbines. It invites any company who either owns or operates one or more gas turbines to attend yearly meeting. Simply contact any one of the member companies for details.

The next meeting will be in Houston, Texas, in the spring of 1961 and will be sponsored by Truckline Gas Company.

Wyman-Gordon makes a majo
Now parts are being forged i



Nickel-base
high-temperature alloy
45" diameter
520 pounds

BROAD RANGE OF GAS TURBINE COMPONENTS ALSO BEING PRODUCED IN:

- Low-Alloy, High-Strength Steels
- Intermediate-Temperature Alloys
- Titanium and Refractory Metals
- Aluminum and Magnesium

High-strength steel
19" diameter
143 pounds

PHYSICAL PROPERTIES

	ALLOY*	TEST TEMPERATURE °F.	HEAT TREAT	GUARANTEED MINIMUM ULTIMATE TENSILE STRENGTH PSI	GUARANTEED MINIMUM 0.2% YIELD STRENGTH PSI	GUARANTEED MINIMUM ELONGATION %	TYPICAL VALUES ULTIMATE TENSILE STRENGTH PSI	TYPICAL VALUES 0.2% YIELD STRENGTH PSI	TYPICAL VALUES ELONGATION %
TENSILE AND YIELD STRENGTHS	Waspaloy	RT	A	175,000	120,000	15.0	194,000	136,000	24.0
		1000	A	162,000	112,000	13.0	175,000	124,000	23.0
	René 41	RT	B	180,000	132,000	12.0	200,000	150,000	15.0
		1400	B	135,000	115,000	13.0	145,000	125,000	18.0
	Astroloy	RT	C	190,000	138,000	10.0	205,000	152,000	12.0
		1400	C	150,000	122,000	12.0	160,000	132,000	15.0
	U-500	RT	D	175,000	120,000	10.0	195,000	135,000	12.0
		1400	D	125,000	105,000	12.0	140,000	120,000	15.0
	M-252	RT	B	170,000	115,000	15.0	185,000	125,000	20.0
		1000	B	160,000	105,000	15.0	165,000	115,000	22.0

	ALLOY*	TEMPERATURE STRESS	GUARANTEED MINIMUM	TYPICAL VALUES
STRESS RUPTURE	Waspaloy	1350°F.—70,000 psi	70 hours—6% Elongation	130 hours—16% Elongation
	René 41	1350°F.—85,000 psi	30 hours—8% Elongation	60 hours—15% Elongation
	Astroloy	1800°F.—20,000 psi	20 hours—7% Elongation	35 hours—12% Elongation
	Udimet 500	1650°F.—25,000 psi	30 hours—6% Elongation	55 hours—12% Elongation
	M-252	1500°F.—40,000 psi	30 hours—8% Elongation	55 hours—16% Elongation

NOTE: The guaranteed minimums are based upon radial and tangential test locations.

COMPOSITION AND HEAT TREATMENT

	ALLOY*	ELEMENTS C	Cr	Mo	Co	Ti	Al	B	Ni
CHEMISTRY	Waspaloy	.08	19.0	4.3	13.5	3.0	1.4	.004	Balance
	René 41	.08	19.0	10.0	11.0	3.1	1.6	.004	Balance
	Astroloy	.05	15.0	5.0	15.0	3.5	4.3	.030	Balance
	Udimet 500	.07	18.5	5.0	18.3	3.0	3.0	.003	Balance
	M-252	.15	20.0	10.0	10.0	3.0	1.3	.002	Balance

HEAT TREATMENT	A.	1850°F.—4 hours—OQ, 1550°F.—2 hours—AC, 1400°F.—16 hours—AC
	B.	1950°F.—4 hours—AC, 1400°F.—16 hours—AC
	C.	2100°F.—½ hour—AC, 1400°F.—16 hours—AC
	D.	1975°F.—4 hours—AC, 1500°F.—24 hours—AC, 1400°F.—16 hours—AC

NOTE: Refer to appropriate heat treat code in Tensile & Yield Strength table.

*Waspaloy: Pratt & Whitney Aircraft Corp.; René 41, Astroloy and M-252: General Electric Company; Udimet 500: Metals Division, Kelsey-Hayes Company.

contribution to gas turbine progress . . .

these new Superalloys with Guaranteed Minimum Properties

permits designing to higher operating stresses . . . increased efficiency . . . greater component reliability for every gas turbine application

Rapid progress in developing the gas turbine has materially extended application of this prime power source to areas other than aircraft. Significant contributions in forging techniques and metallurgical advancements by Wyman-Gordon have in part made this possible.

Now designers are free to explore new frontiers of turbine performance unhampered by former material limitations. The high temperature alloys shown here exhibit outstanding tensile and stress rupture strengths in elevated temperature environments. These alloys have been forged into discs, shafts, rings, blades and vanes on a production scale.

Wyman-Gordon offers these alloys to *guaranteed minimum properties* for such vital components. This is made possible by the broad experience in forging parts from all difficult-to-work materials, including a complete range of low-alloy, high-strength steels; intermediate temperature alloys; light metals; titanium and the refractory materials.

Our metallurgists and forging engineers are prepared to counsel on turbine components . . . evaluating material requirements and forging of existing designs and development parts. For assistance or additional information on Superalloy forgings, write—Product Manager, Turbine Applications, Wyman-Gordon Company, Worcester, Massachusetts.

WASPALOY

•

RENÉ 41

•

ASTROLOY

•

UDIMET 500

•

M-252

MEETING DESIGNERS' NEEDS
IN EVERY TURBINE APPLICATION

- Aircraft and Missile
- Nuclear Power and Propulsion
- Rail and Highway Transport
- Power Generation
- Air Supply and Pumping
- Pipeline Boosting
- Auxiliary Service
- Automotive
- Marine Propulsion
- Stationary Power

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FORGINGS

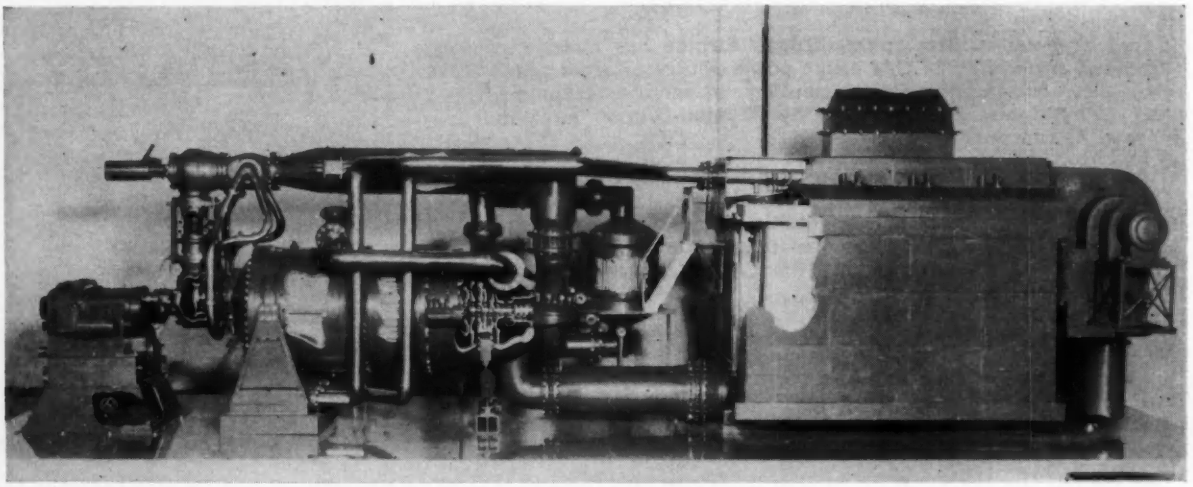
of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS — WORCESTER MASSACHUSETTS — DETROIT MICHIGAN

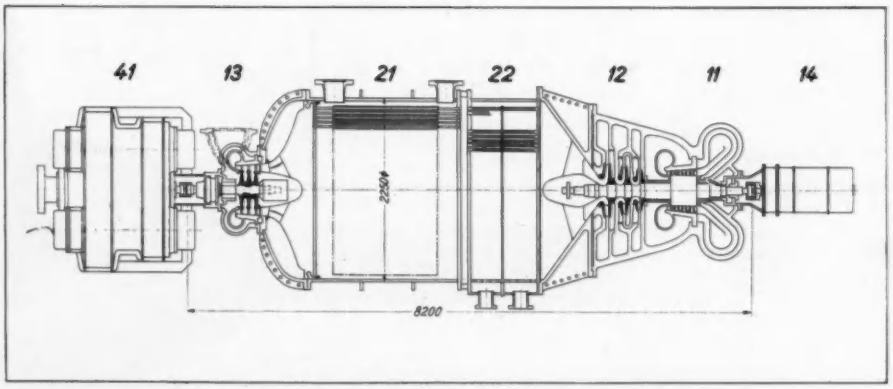
GRAFTON MASSACHUSETTS — LOS ANGELES CALIFORNIA — PALO ALTO CALIFORNIA — FORT WORTH TEXAS

past...present...FUTURE!

Highlighting some significant milestones in Gas Turbine Industry's accelerated evolution.



TYPICAL 10,000-12,000-shp marine closed-cycle plant designed by Escher Wyss. Professor-Doctor J. Ackeret and Dr. Curt Keller are known throughout the world as the inventors of this type of gas turbine plant. Model shown here is cutaway version of one built for Mitsui Shipbuilding & Engineering Company Ltd. See sectional view below.

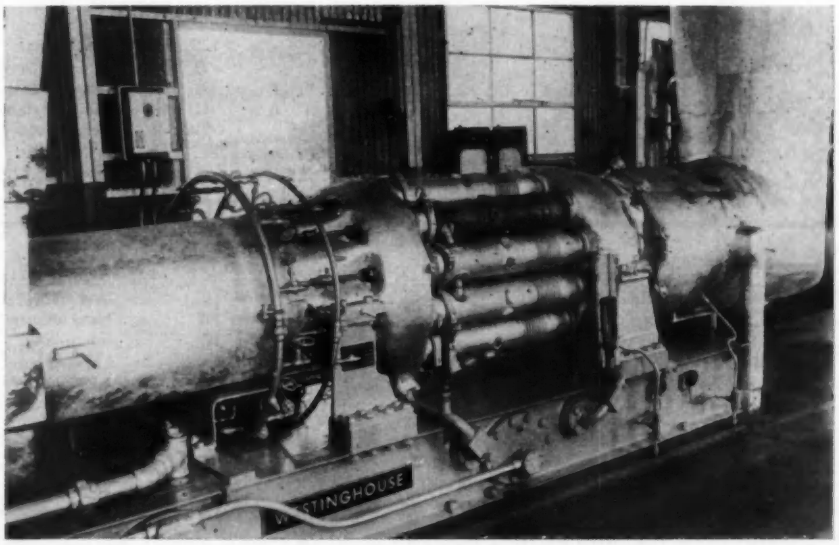


SECTIONAL VIEW of the gas turbine seen in the left two-thirds of above picture. (11) Compressor Turbine (12) Compressor (radial) (13) Power Turbine (14) Starter (21) Recuperator (extended surface) (22) Cycle Cooler (41) Reduction Gear

DR. ADOLPH MEYER, now retired from Brown Boveri, was responsible for the Neuchatel 4-MW unit—the first successful installation. He is also responsible for many more large gas turbine units that followed this initial installation. His many friends recognize him as "the father of the large gas turbine" — a fine gentleman, a brilliant engineer. Here he is shown presenting a paper in New York in 1946 at a meeting of the Gas Turbine Power Division of ASME.

AIRCRAFT TURBINE MANUFACTURERS are moving into the stationary field. This "TE-1" unit is typical, consisting of two 3000-hp Allison T56 engines. This unit was shipped by air 30-days after receipt of order from Martin's missile division at Denver. It was in operation 6-days later on March 26, 1960.

WESTINGHOUSE's 1800-hp gas turbine was installed on the Mississippi River Fuel Corp. system in May of 1949. Unit was first installed at Wilmar, Ark., then moved to Bonne Terre, Mo., compressor station. Westinghouse industrial gas turbines have undergone many design changes since this "granddaddy of gas turbines" was built. It operated 62,280-hr as of January 1, 1960. According to our records this Westinghouse turbine leads the world in total service hours! Runner up is Brown Boveri's unit at Dudelange Blast Furnace with a record of 58,282-hr service.



BIG GAS TURBINES

This list of gas turbine installations is worldwide in scope. It includes all installations of 1800-horsepower and up and covers all applications except aircraft uses. Manufacturers both here and abroad were contacted for this data. Our thanks to them for their excellent co-operation. Also, our thanks to James L. Eager, assistant public relations supervisor, Texas Eastern Transmission Corporation, Houston, Texas, for his suggestion to the Consulting Editor that resulted in this listing.

This is believed to be the most comprehensive listing of gas turbine installations published to date. A supplement to this list will be published each year. We encourage manufacturers, operators and our readers to advise us of any additions, or changes that should be made. We want to make this list as useful as possible and any suggestions along these lines will be appreciated.

The list tells its own story . . . a magnificent record of achievement of which the gas turbine industry can be proud . . . a record others must note and respect . . . a record that shows . . .

THERE IS A GAS TURBINE INDUSTRY!

SOME TOTALS

Operating Companies	195
Installations as listed	250
Manufacturers	24
Units — Total	592
Units, Generator-Drive	256
Units not Generator-Drive	336
Units, Single-Shaft	328
Units, Multi-Shaft	264
Units, IC or H or both	207
Units, Closed-CC	12
MW Capacity as listed	2319.42
MW Capacity as listed Converted to HP	3,407,080
HP and EHP as listed	2,264,100
Grand Total, HP	5,671,180

20 COMPANIES OVER 60,000hp

*Note below—This plant has only one turbine, DeLaval of Sweden is building it.

Purchaser or Operator		Units	Horsepower
7A	Arabian American Oil	14	117,200
9A	Asiatic Petroleum Corp.	8	82,700
3B	BEWAG (B.K.L.AG) Germany	2	86,000
4B	British Columbia Electric Company	4	155,200
5B	British Columbia Power Commission	4	102,000
23C	Creole Petroleum Corp.	41	352,200
2E	City of Edmonton, Canada	2	86,000
8E	El Paso Natural Gas Co.	32	160,000
1H	Hammarsforsens Power Co., Sweden	1*	60,700
4I	Iraq Petroleum Co.	10	88,200
4N	NEWAG, Austria	3	91,700
7N	North-Eastern Power Supply Co., Switzerland	4	88,800
2R	Royal Navy	17	115,500
6S	Shell Petroleum Co.	16	141,940
11S	Societa Elecrtrica Selt-Valdarno, Italy	2	71,800
22S	Stadtwerke Bremen, Germany	2	86,000
1T	Tennessee Gas Transmission Co.	10	72,800
3T	Texas Eastern Transmission Corp.	34	249,800
5U	Union Pacific Railroad	41	250,490
2W	West German Navy	12	144,000

LEGEND

ABBREVIATIONS

AC	=	Air Compressor Drive
AS	=	Air Supply
BF	=	Blast Furnace
CC	=	Closed Cycle (All units are open cycle unless marked CC)
CH	=	Central Heating
E	=	Extraction Unit
ehp	=	Equivalent Horsepower
GC	=	Gas Compressor Drive
Gen	=	Generator
Gf	=	Gasifier
H	=	Exhaust Heat Exchanger
hp	=	Horsepower

ABBREVIATIONS

(hp)	=	MW/.7 accounting for generator efficiency
HT	=	Heat exchangers used for heating or cooling or both
IC	=	Intercooler
Loco	=	Locomotive, *= Test equal to 5000 miles to date
MW	=	1,000,000 Watts = hp x .7
No.S	=	Number of Separate Turbine Shafts
OP	=	Oil Pump
Pr	=	Process
SCFM	=	Standard Cubic Feet per Minute x 1000
Ship	=	Ship
Test	=	Testing 5500 hours
WP	=	Water Pump

CODE IDENTIFYING MANUFACTURERS
(Including Production Data of Units Built and on Order)

Code		MANUFACTURERS	Units Built	HP
A	—	Allison Division, General Motors Corp., Indianapolis, Ind.	2	6,000
AEG	—	Allgemeine Elektricitaets-Gesellschaft, Germany.	1	8,300
AEI	—	Associated Electrical Industries Ltd., Manchester, England	34	200,660
BB	—	Brown Boveri Corp., New York and Brown Boveri Co., Switzerland (All BB units give year of order instead of in service).	146	2,059,650
BS	—	Bristol Siddeley Engines, Ltd., Filton, England	1	4,250
C	—	Clark Bros., Co., Olean, N. Y.	31	277,310
CB	—	Cooper-Bessemer Corp., Mt. Vernon, Ohio	1	13,200
D	—	DeLaval Ljungstrom Turbine Co., Finspang, Sweden	7	179,800
E	—	English Electric Co., London, England	25	165,850
EW	—	Escher Wyss, Zurich, Switzerland	2	35,100
FD	—	Fuji Denki, Tokyo, Japan (EW Licensee)	2	20,490
FT	—	Franco Tosi S.P.A., Legnano, Italy (AEI Licensee)	1	7,380
G	—	Gutenhoffnungsh Hutte, Sterkrade, Germany (EW Licensee)	4	41,890
GE	—	General Electric Company, Schenectady, N. Y.	206	1,654,360
JB	—	John Brown, Clydebank, Scotland (EW Licensee)	2	5,630
MAN	—	Maschinenfabrik Augsburg-Nurnberg A.G., Augsburg, West Germany	1	7,500
MS	—	Mitsui Shipbuilding Co., Japan (EW Licensee)	1	10,000
N	—	Nuove Reggiane, Reggio Emilia, Italy (AEI Licensee)	1	4,500
P	—	C. A. Parsons, Newcastle-Upon-Tyne, England	5	46,040
P&W	—	Pratt & Whitney Aircraft, East Hartford, Conn.	(see CB)	
R	—	Societe Rateau, Paris, France	1	8,600
S	—	Sulzer Brothers Ltd., Winterthur, Switzerland	19	159,150
T	—	Tokyo Shibaura Electric Co., Ltd., Tokyo, Japan	2	9,380
W	—	Westinghouse Electric Corp., Philadelphia, Pa.	97	746,140

NOTE: Code showing owners identity and location of installations follows listing below.

Gas Turbine Installations, 1800-hp or over

ITEM	NO	MFG	YEAR	USE	NO.S	HT	RATING NORMAL	RATING MAX
1A1	1	E	60	Gen	2	CH	1.85MW	3000hp
2A1	1	W	55	AS	1	—	1800hp	
2A2	1	BB	55	Pr	1	—	28SCFM	4800ehp
3A1	1	W	59	Gen	1	—	10MW (14,300hp)	
3A1	1	BB	59	Gen	2	IC	19.62MW (28,000hp)	
3A2	1	BB	45	AC	1	H	2870hp	
3A2	2	S	60	Gen-BF	1	H	4.3MW	5000hp
4A1	1	BB	45	Gen	1	H	1.25MW (1800hp)	
5A1	2	GE	57	GC	1	—	7000hp	
6A1	1	BB	59	Pr	1	—	28SCFM 4800ehp	
7A1	5	BB	51-52	Gen	1	—	5MW (7200hp)	
7A1	1	C	59	Gen	2	—	6.75MW (9700hp)	
7A1	2	GE	57	OP	2	—	7000hp	
7A1	5	C	59	GC	2	—	8700hp	
7A1	1	S	61	GC	1	—	14,000hp	

ITEM	NO	MFG	YEAR	USE	NO.S	HT	RATING NORMAL	RATING MAX
8A1	1	BB	48	Gen	1	H	5.4MW	5.92MW (8500hp)
9A1	1	W	57	Gen	1	—	5MW (7200hp)	
9A2	2	GE	54	Gen	1	—	5MW (7200hp)	
9A3	1	GE	—	Gen	1	—	21.5MW (30,700hp)	
9A4	2	W	59	GC	1	—	8000hp	
9A5	2	W	59	Gen	1	—	5MW (7200hp)	
10A1	3	E	61	Gen	2	—	1.79MW 2870hp	
11A1	1	GE	53	GC	2	H	5000hp	
12A1	1	BB	57	Pr	1	—	25SCFM 4300hp	
13A1	1	W	60	Gen	1	—	5.5MW (7900hp)	
1B1	2	GE	50-52	Gen	2	H	5MW (7200hp)	
2B1	3	AEI	—	Gen	1	—	2.2MW	2950hp
2B1	4	E	61	OP	2	—	6000hp	9000hp
3B1	2	BB	57	Gen	2	IC	24MW	30MW (43,000hp)

Gas Turbine Installations, 1800-hp and over

ITEM	NO	MFG	YEAR	USE	NO.S	HT	RATING NORMAL	RATING MAX
4B1	4	BB	56	Gen	2	IC	23MW	27MW (38,800hp)
5B1	1	GE	57	Gen	1	—	19.4MW (27,700hp)	
5B1	1	GE	57	Gen	1	—	19.9MW (28,500hp)	
5B1	2	GE	58-59	Gen	1	H	16MW (22,900hp)	
6B1	1	E	60	Gen	2	H	1.9MW	2870hp
7B1	1	BB	48	Loco	1	H	2500hp	
1C1	1	GE	57	GC	1	—	7000hp	
2C1	2	BB	58-59	Pr	1	—	18SCFM 3000ehp	
3C1	1	GE	58	GC	1	—	7850hp	
4C1	1	BB	55	Gen	1	—	6.2MW	10MW (14,300hp)
4C2	1	BB	52	Gen	1	—	6MW	7.68MW (11,000hp)
5C1	1	GE	58	GC	1	—	7000hp	
6C1	1	AEI	52	Gen	2	IC-H	15MW 20,100hp	
6C1	1	P	55	Gen	3	H	15MW (21,500hp)	
7C1	1	GE	50	Gen	1	—	3.5MW (5000hp)	
8C1	3	GE	51-53	Gen	2	H	5MW (7200hp)	
9C1	2	BB	58	Gen	1	—	6MW (8600hp)	
10C1	2	BB	55-56	Pr	1	—	18SCFM 3000ehp	
11C1	2	GE	—	Gen	1	—	5MW (7200hp)	
12C1	1	W	60	Gen	1	—	5.5MW (7900hp)	
13C1	1	G	59	Gen-CH	1	CC	6MW	6.6MW (9500hp)
14C1	1	S	61	Gen-BF	1	H	8MW (11,400hp)	
14C2	1	S	58	Gen-BF	1	H	8MW (11,400hp)	
15C1	1	C-B (P&W)	60	GC	3	—	10,500hp	13,200hp
16C1	3	BB	54-55	Gen	1	—	6.2MW (8900hp)	
16C1	1	C	56	Gen	2	—	6.2MW (8900hp)	
17C1	1	BB	55	Pr	1	—	18SCFM 3000ehp	
18C1	2	BB	58	Gen	1	—	4.7MW (6740hp)	
19C1	2	GE	53-54	Gen	2	H	5MW (7200hp)	
19C2	2	GE	53	Gen	2	H	5MW (7200hp)	
20C1	1	BB	60	Gen	1	—	15.25MW (21,900hp)	
21C1	2	BB	45	Gen	1	—	4MW (5700hp)	
22C1	2	GE	58	Gen	1	H	8.7MW (12,500hp)	
22C2	10	GE	54	GC	2	—	6000hp	
22C2	26	W	56-60	GC	1	—	8000hp	
22C2	1	GE	57	GC	1	—	13,400hp	
22C2	2	GE	58-59	Gen	1	—	16MW (22,900hp)	
23C1	1	GE	58	Gen	1	—	5MW (7200hp)	
24C1	1	BB	58	Pr	1	—	18SCFM 3000ehp	
1D1	2	W	59	Gen	1	—	5MW (7200hp)	
1D2	2	W	59	Gen	1	—	5MW (7200hp)	
2D1	4	GE	—	Gen	1	—	5MW (7200hp)	
3D1	1	BB	55	AC-BF	1	H	105SCFM 8800ehp	
3D2	1	MAN	60	Gen	2	H	5MW	7500hp
3D2	2	BB	55-57	AC-BF	1	H	93SCFM 7900ehp	
1E1	2	AEI	54-56	Gen	1	H	2.5MW	3350hp
2E1	2	BB	55	Gen	2	IC	20MW	30MW (43,000hp)
3E1	1	BB	55	Gen	2	IC	20MW (28,700hp)	
3E1	1	GE	59	Gen	1	—	21.5MW (30,700hp)	
4E1	3	D	60	Gen	3	—	7.5MW (10,700hp)	
5E1	1	R	59	Gen	2	—	6MW (8600hp)	
5E2	1	BB	59	Gen	1	—	17.2MW (24,700hp)	
5E3	1	EW	Test	Gen	2	CC	12.5MW (17,900hp)	
5E4	1	BB	53	Gen	1	—	5.9MW (8450hp)	
6E1	2	BB	55	Gen	1	—	12MW (17,200hp)	
7E1	1	W	55	Gen	1	—	5MW (7200hp)	
8E1	2	BB	59	Gen	1	—	10.3MW (14,800hp)	
9E1	2	GE	53	GC	2	H	5000hp	
9E2	3	GE	52-53	GC	2	H	5000hp	
9E3	3	GE	53	GC	2	H	5000hp	
9E4	3	GE	53	GC	2	H	5000hp	
9E5	3	GE	53	GC	2	H	5000hp	
9E6	2	GE	57-58	GC	2	H	5000hp	
9E7	2	GE	57-58	GC	2	H	5000hp	
9E8	3	GE	53	GC	2	H	5000hp	
9E9	2	GE	52-53	GC	2	H	5000hp	
9E10	3	GE	52-53	GC	2	H	5000hp	
9E11	3	GE	52-53	GC	2	H	5000hp	
9E12	3	GE	52-53	GC	2	H	5000hp	
10E1	2	GE	57-58	Gen	1	—	5MW (7200hp)	
11E1	1	BB	45	Gen	2	IC-H	10MW (14,300hp)	
11E1	2	BB	57	Gen	1	—	10.7MW (15,400hp)	
12E1	1	BB	57	Gen	2	IC	17.5MW	20MW (28,700hp)
13E1	2	E	60	Loco*	2	H	2750hp	2950hp
14E1	1	EW-G	56	Gen-CH	1	CC	2MW	2.3MW (3290hp)
15E1	1	E	58	GC	2	CH	2625hp	2850hp
16E1	1	W	57	GC	1	—	3000hp	
16E2	3	C	57	GC	2	H	8500hp	
17E1	1	GE	53	GC	1	—	5700hp	
17E1	2	GE	58	GC	1	—	9810hp	
1F1	1	BB	57	Pr	1	—	28SCFM 4800ehp	
2F1	1	W	60	GC	1	—	10,000hp	
1G1	1	GE	56	Gen	1	—	5MW (7200hp)	
2G1	1	D	62	Gen	3	—	11MW (15,700hp)	
3G1	4	BB	56-58	Gen	1	—	6.1MW	7.3MW (10,400hp)
4G1	1	GE	57	Gen	1	—	15MW (21,500hp)	
4G1	1	GE	57	Gen	1	—	16MW (22,900hp)	
5G1	2	GE	59	Gen	1	—	5MW (7200hp)	
1H1	1	D	62	Gen	3	IC	42.5MW (60,700hp)	
2H1	1	EW-FD	57	Gen	1	CC	2MW	2.3MW (3290hp)
3H1	2	W	58	AC	2	—	5300hp	
3H1	1	GE	58	GC	1	—	12,150hp	
4H1	2	BB	56-57	Gen	1	H	15MW (21,500hp)	
5H1	1	BB	55	Gen-AC	2	H	14MW (20,000hp)	
1I1	2	GE	—	Gen	1	—	7.5MW (10,700hp)	
2I1	2	C	—	Gen	2	—	6.75MW (9700hp)	
3I1	2	BB	45	Gen	1	—	3.95MW	4.7MW (6740hp)
3I1	3	AEI	59-60	Gen	1	—	4MW	5360hp
4I1	4	C	—	OP	2	—	9300hp	
4I2	3	W	60	OP	2	—	8000hp	
4I2	3	E	60	WP	2	—	6000hp	9000hp
5I1	1	FT-AEI	59	Gen	1	H	5.5MW 7380hp	
6I1	1	AEI	59	Ship	2	—	4500hp	
6I1	1	N-AEI	—	Ship	2	—	4500hp	
1J1	1	MS	—	Ship	1	CC	10,000hp	
1K1	1	BB	55	Gen	2	IC	27.5MW	29.6MW (42,500hp)
2K1	2	BB	57	Gen	1	—	7.6MW	11MW (15,700hp)
2K1	2	W	60	GC	1	—	7800hp	
1L1	1	W	60	GC	1	—	3000hp	
2L1	1	W	55	Gen	1	—	1.25MW (1800hp)	
3L1	2	BB	56-58	Gen	1	—	7.5MW	10MW (14,300hp)
4L1	1	EW-G	—	Gen-CH	1	CC	6MW	6.6MW (9500hp)
1M1	1	AEG	60	Gen-AC	1	H	5.44MW	8300hp
1M2	1	BB	55	AC-BF	1	H	78SCFM 6700ehp	
2M1	1	S	61	Gen	1	—	6.1MW (8750hp)	
3M1	1	W	—	Gen	1	—	5MW (7200hp)	
4M1	2	A	60	AC	1	—	3,000hp	3,460hp
5M1	1	T	56	Gen	1	H	2MW	2680hp
6M1	7	S	—	GC	2	H	4000hp	
7M1	2	GE	58	Gen	1	—	9.1MW (13,000hp)	
8M1	1	BB	59	Gen	1	H	4.9MW (7000hp)	
8M1	1	T	61	Gen	1	H	5MW	6700hp
9M1	5	W	54-59	Gen	1	—	5MW (7200hp)	
10M1	1	E	57	Gen	2	—	1.875MW	2870hp
10M1	1	AEI	55	Gen	1	—	2.5MW	3350hp
11M1	1	BB	55	Gen-AC	1	H	7.3MW (10,400hp)	
12M1	2	E	58	Gen	4	IC	20MW (28,700hp)	
13M1	1	AEI	55	Gen	1	—	2MW	2680hp
14M1	1	E	56	Gen	2		1.75MW (2500hp)	
14M2	1	E	56	Gen	2	H	1.75MW (2500hp)	
15M1	1	BB	53-56	Pr	1	—	18SCFM	3000ehp
16M1	1	W	49	GC	1	—	1800hp	
17M1	1	GE	58	Gen	1	—	10MW (14,300hp)	
18M1	2	GE	53	Gen	1	—	4MW (5700hp)	
19M1	1	BB	58	Gen	1	—	7.6MW (10,840ehp)	
20M1	1	BB	59	Pr	1	—	24SCFM 4200ehp	
1N1	1	JB	60	Gen	1	CC	2MW	2680hp
2N1	1	P	55	Air	1	—	2710ehp	
2N1	1	P	56	Gen	2	H	10MW (14,300hp)	
3N1	1	BB	38	Gen	1	—	4MW (5700hp)	
4N1	2	BB	56	Gen	2	IC	25MW (35,900hp)	
4N2	1	BB	56	Gen	1	—	13.9MW (19,900hp)	
5N1	2	BB	54-59	Gen-AC	2	H	5.8MW (8300hp)	
6N1	1	FD	—	Gen	1	CC	10MW	12MW (17,200hp)
7N1	1	BB	46	Gen	2	IC	13MW (18,600hp)	
7N1	1	BB	46	Gen	2	IC	27MW (38,800hp)	
7N2	2	S	59-60	Gen	1	H	11MW (15,700hp)	
8N1	1	JB	60	Gen	1	CC	2.2MW	2950hp
9N1	4	GE	53-54	GC	2	H	5700hp	
9N2	4	GE	53-54	GC	2	H	5700hp	
10N1	1	W	61	Gen	1	—	15MW (21,500hp)	
11N1	1	EW	60	Gen-CH	1	CC	10MW	12MW (17,200hp)
101	1	G	60	Gen-CH	1	CC	12.5MW	13.7MW (19,600hp)
201	2	C	57	Gf	1	—	9300ehp	
301	1	GE	49	Gen	1	—	3.5MW (5000hp)	
301	1	GE	52	Gen	1	—	4MW (5700hp)	
401	1	BB	55	Pr	1	—	18SCFM 3000ehp	
501	2	GE	58	Gen	1	—	16MW (22,900hp)	

ITEM	NO	MFG	YEAR	USE	NO.S	HT	RATING NORMAL	MAX
6G1	1	BB	55	Gen-AC	2	H	14MW (20,000hp)	
7G1	1	BB	59	Gen	1	—	6.5MW (9300hp)	
1P1	2	BB	56	Gen	1	—	5.7MW	6.75MW (9700hp)
2P1	1	P	54	Gen	2	H	2.5MW (3600hp)	
3P1	3	GE	58	GC	1	—	12,150hp	
4P1	4	W	57	Gf	1	—	7000hp	
5P1	4	W	60-61	Gen	1	—	5.5MW (7900hp)	
6P1	1	W	60	Gen	1	—	22MW (31,570hp)	
7P1	1	BB	57	Pr	1	—	18SCFM 3000eph	
8P1	1	GE	51	Gen	2	H	5MW (7200hp)	
9P1	2	BB	56	Gen	2	IC	20MW (28,700hp)	
1R1	1	GE	60	Gen	1	—	16.5MW (23,600hp)	
2R1	4	AEI	52-59-60	Ship	2	—	4500hp	
2R1	13	AEI	59 & —	Ship	2	—	7500hp	
1S1	1	W	61	Gen	1	—	22MW (31,570hp)	
2S1	1	BB	55	Pr	1	—	24SCFM 4200ehp	
3S1	2	BB	56	Gen	1	—	6.2MW	10MW (14,300hp)
4S1	1	BB	51	Gen	1	—	5MW (7200hp)	
4S1	2	BB	53	Gen	1	—	5.75MW (8200hp)	
5S1	6	BB	55-57	Gen	1	—	6MW (8600hp)	
6S1	1	AEI	—	Gen	1	—	4.5MW	6050 hp
6S2	1	E	60	Gen	2	—	1.77MW	2870 hp
6S3	3	E	60	Gen	2	—	1.77MW	2870 hp
6S4	1	AEI	55	Gen	1	—	1.75MW	2350
6S4	2	C	—	GC	2	—	9300hp	
6S4	5	C	—	GC	2	—	8700hp	
6S4	2	BB	56-57	Gen	2	IC	20MW	22MW (31,570hp)
6S5	1	E	—	Gen	2	—	1.77MW	2870hp
7S1	1	AEI	59	Ship	2	IC-H	5500hp	
8S1	1	BB	54	Gen	1	H	2.5MW(3600hp)	
9S1	1	BB	57	Gen-AC	2	H	14MW (20,000hp)	
10S1	1	P	56	Gen	2	H	1.56MW	2.75MW (3930hp)
11S1	2	BB	54	Gen	2	IC	22.5MW	25MW (35,900hp)
12S1	2	BB	58	Pr	1	—	28SCFM 4800ehp	
13S1	1	BB	55	Gen	2	IC	22.5MW	25MW (35,900hp)
14S1	1	BB	43	Gen	2	IC	10MW (14,300hp)	
15S1	1	S	60	Gen-BF	1	H	8MW (11,400hp)	
16S1	1	S	59	Gen-BF	1	CH	8MW (11,400hp)	
17S1	2	S	55-56	Gen-BF	1	IC-H	7.5MW (10,700hp)	
18S1	1	BB	55	Gen-AC	2	H	14MW (20,000hp)	
19S1	1	BB	57	Pr	1	—	15SCFM 2500ehp	
20S1	1	GE	53	GC	2	H	5000hp	
20S2	1	GE	53	GC	2	H	5000hp	
21S1	1	BS	59	Gen	2	—	3MW	4250hp
22S1	2	BB	57	Gen	2	H	25MW	30MW (43,000hp)
23S1	1	BB	54	Pr	1	—	28SCFM 4800ehp	
24S1	1	BB	55	Pr	1	—	14SCFM 2400ehp	
25S1	1	BB	54	Pr	1	—	18SCFM 3200ehp	
26S1	2	W	56	AC-GC	1	—	3000hp	
26S2	2	W	56	AC-GC	1	—	3000hp	
27S1	1	D	59	Gen	3	IC	40MW (57,000hp)	
28S1	1	BB	55	Gen-AC	2	H	7.3MW (10,400hp)	

ITEM	NO	MFG	YEAR	USE	NO.S	HT	RATING NORMAL	MAX
29S1	2	BB	40	Pr	1	—	40SCFM 6000ehp	
1T1	4	GE	55-58	GC	2	H	6700hp	
1T2	1	GE	58	GC	2	H	6700hp	
1T2	1	GE	59	GC	1	—	13,400hp	
1T3	2	GE	58-59	GC	2	H	6700hp	
1T4	1	GE	56	GC	2	H	5000hp	
1T4	1	W	59	GC	1	H	7500hp	
2T1	1	BB	56	Pr	1	—	24SCFM 4200ehp	
3T1	4	GE	56-58	GC	2	H	7600hp	
3T2	4	GE	57-58	GC	2	H	7600hp	
3T3	1	GE	57	GC	2	H	7600hp	
3T3	1	GE	58	GC	2	H	7000hp	
3T4	4	GE	57-58	GC	2	H	7600hp	
3T5	4	GE	56-58	GC	2	H	7600hp	
3T6	1	GE	58	GC	1	—	13,400hp	
3T7	3	W	57	GC	2	H	5000hp	
3T8	1	GE	58	GC	1	—	13,400hp	
3T9	1	GE	58	GC	1	—	13,400hp	
3T10	3	W	56-57	GC	2	H	5000hp	
3T11	3	W	57	GC	2	H	5000hp	
3T12	3	W	55-57	GC	2	H	5000hp	
3T13	1	GE	58	GC	1	—	13,400hp	
4T1	1	GE	52	Gen	2	H	3.5MW (5000hp)	
5T1	1	BB	57	Gen	2	IC	27.5MW	29.6MW (42,500hp)
6T1	7	GE	57-58	OP	2	—	7000hp	
7T1	3	C	60	GC	2	H	8370hp	
8T1	1	C	—	Gen	2	H	6.75MW (9700hp)	
9T1	1	GE	55	GC	2	H	6700hp	
9T2	1	GE	56	GC	2	H	6700hp	
9T3	1	GE	56	GC	2	H	6700hp	
1U1	1	BB	57	Gen-AC	2	H	7MW (10,000hp)	
2U1	1	BB	60	Pr	1	—	16SCFM 2700ehp	
3U1	2	GE	58	AC	1	—	7500hp	
4U1	1	BB	49	Gen	1	—	4.4MW (6300hp)	
5U1	27	GE	52-54	Loco	1	—	4870hp	
5U1	14	GE	58-60	Loco	1	—	8500hp	
6U1	1	BB	56	Gen-AC	2	H	12MW (17,200hp)	
7U1	1	GE	58	GC	2	H	13,400hp	
8U1	1	GE	53	GC	2	H	5700hp	
9U1	1	W	52	AC	1	—	1800hp	
9U1	1	W	55	Gen	1	—	5MW (7200hp)	
10U1	1	C	—	Gen	2	—	6.75MW (9700hp)	
11U1	2	AEI	57	Ship	2	—	4000hp	4500hp
11U1	1	C	58	Gen	2	—	5.5MW (7900hp)	
11U1	5	W	57	Ship	2	H	7500hp	
12U1	1	GE	56	Ship	2	H	6000hp	
13U1	1	W	—	Ship	2	CC	20,000hp	
14U1	1	W	60	E-BF	1	H	15,000hp	
1V1	1	BB	58	Gen	1	—	5.8MW (8300hp)	
1V2	2	BB	45	Gen	1	H	1.65MW (2370hp)	
1V2	2	BB	50-52	Gen	1	—	5MW (7200hp)	
1V2	1	BB	57	Gen	1	—	5.9MW (8450hp)	
1W1	1	BB	55	Gen	1	—	6.2MW	9MW (12,800hp)
2W1	12	BB	56	Ship	?	?	12,000hp	
3W1	2	W	52 & 58	Gen	1	—	5MW (7200hp)	
3W2	1	GE	54	Gen	1	—	5MW (7200hp)	
1Y1	1	D	57	Gen	3	—	10MW (14,300hp)	

IDENTITY OF OWNERS AND LOCATION OF INSTALLATIONS

CODE	OPERATING or PURCHASING COMPANY
1A1	ALBERTA PROVINCE—DEPT. OF PUBLIC WORKS, Edmonton, Canada
	ALLIED CHEMICAL & DYE CORPORATION
2A1	Hopewell, Va.
2A2	Omaha, Nebraska
	ALTOS HORNOS
3A1	Monclova, Mexico
3A2	Baracaldo, Spain
	AMALGAMATED ICE FACTORIES AND GOLD STORES, S.A.E.
4A1	Alexandria, Egypt
5A1	AMERICAN CYANAMID COMPANY, Avondale, La.
6A1	ANIC RAVENNA, Italy

CODE	OPERATING or PURCHASING COMPANY
7A1	ARABIAN AMERICAN OIL COMPANY, Saudi Arabia
8A1	ARBED, DIVISION de DUDELANGE, Luxemburg
	ASIATIC PETROLEUM CORPORATION
9A1	(Brunei), Borneo
9A2	La Concepcion, Venezuela
9A3	Lake Maricaibo, Venezuela
9A4	La Paz, Venezuela
9A5	Puerto Miranda, Venezuela
10A1	ASSAM OIL COMPANY, Assam, India
11A1	ATLANTIC SEABOARD CORP., Seneca, W. Va.
12A1	ATLAS POWDER CO., Joplin, Mo.
13A1	CITY OF AUSTIN, Minnesota
1B1	BANGOR HYDRO ELECTRIC CO., Veasie, Maine

Identity Of Owners And Location Of Installations

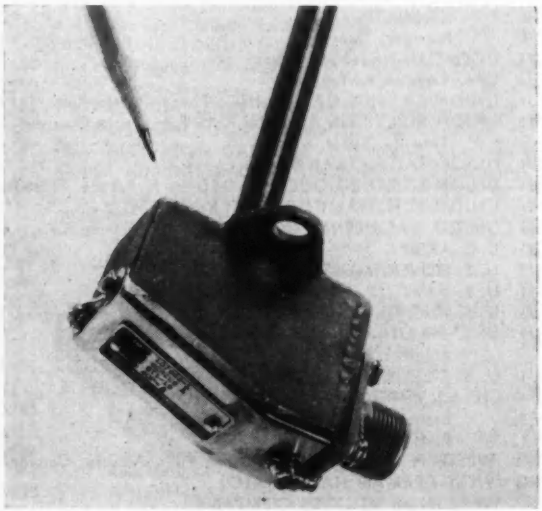
CODE	OPERATING or PURCHASING COMPANY
2B1	BASRAH PETROLEUM CO., Iraq
3B1	BEWAG (B.K.L.AG), Steglitz, Germany
4B1	BRITISH COLUMBIA ELECTRIC CO., LTD., Vancouver, B. C., Canada
5B1	BRITISH COLUMBIA POWER COMMISSION, Chemanius, B. C., Canada
6B1	BRITISH PETROLEUM CO., Grangemouth, Scotland
7B1	BRITISH RAILWAYS. Western Region, England
1C1	CALIFORNIA TEXAS OIL CO., Bahrain Island, Persian Gulf
2C1	CALSPRAY CHEMICAL CORPORATION, Kenniwick, Wash.
3C1	CAMPAGNIE FRANCAISE DE RAFFINAGE, Le Havre, France
	CANADIAN UTILITIES LTD.
4C1	Sturgeon Lake, Alberta, Canada
4C2	Vermilion, Alberta, Canada
5C1	CARBIDE & CARBON COMPANY, Texas City, Texas
6C1	CENTRAL ELECTRICITY GENERATING BOARD, England
7C1	CENTRAL MAINE POWER, Farmingdale, Me.
8C1	CENTRAL VERMONT PUBLIC SERVICE, Rutland, Vermont
9C1	CENTRALES ELECTRICAS del NORTE de SANTANDER, Tibu, Columbia
10C1	CHEMSTRAND CORPORATION, Pensecola, Florida
11C1	CIA LUZ ELECTRICA de BARCELONA, Anaco, Venezuela
12C1	CIA NACIONAL de ELECTRICIDAD S. A., Saltillo, Mexico
13C1	(City of) Coburg, Germany
	S. A. COCKERILL—OUGREE,
14C1	Athus, Belgium
14C2	Seraing, Belgium
15C1	COLUMBIA GULF TRANSMISSION CO., Clementsville, Ky.
16C1	COMISION FEDERAL de ELECTRICIDAD, Mexico (Mobile)
17C1	COMMERCIAL SOLVENTS CORP., Sterlington, La.
18C1	COMPAGNIE FRANCAISE des PETROLES, Hassi Messaoud, Sahara
	CONNECTICUT LIGHT & POWER COMPANY
19C1	Danielson, Conn.
19C2	Thompsonville, Conn.
20C1	CORNIGLIANO S.p.A., Cornigliano, Italy
21C1	CORPORACION PERUANA DEL SANTA, Lima, Chimbote, Peru
	CREOLE PETROLEUM CORPORATION
22C1	Amuay, Venezuela
22C2	Lake Maracaibo, Venezuela
23C1	CRISP COUNTY POWER COMMISSION, Cordele, Ga.
24C1	CUBANA del NITROGENO MATANZAS, Cuba
	DAEE DE SAO PAULO
1D1	Jugillo, Brazil
1D2	Votupranga, Brazil
2D1	DEPARTMENTO de AGUAS ELECTRICA ENERGIA, Florida, Paulista, Brazil
	DORTMUND-HORDER HUTTENUNION A. G.,
3D1	Dortmund, Germany
3D2	Horde, Germany
1E1	EAST AFRICA POWER & LIGHT CO., Nairobi, Kenya
2E1	(City of) EDMONTON, Alberta, Canada
3E1	ELECTRICIDAD de CARACAS, El Convento, Venezuela
4E1	C.A.DE ADMINISTRACION y FOMENTO ELECTRICO, CARACAS, Puerto La Cruz, Venezuela
	ELECTRICITE de FRANCE
5E1	Angers, France
5E2	Brest—Portzic, France
5E3	St. Denis, Paris, France
5E4	St. Dizier, France
6E1	ELECTRICITE et GAZ d'ALGERIE, Santa-Cruz, Algeria
7E1	ELECTRICITY BOARD OF BEIRUT, Lebanon
8E1	ELECTRICITY CORP. OF NIGERIA, Afam
	EL PASO NATURAL GAS COMPANY
9E1	Benson, Arizona
9E2	Casa Grande, Arizona
9E3	San Simone, Arizona
9E4	Vail, Arizona
9E5	Afton, New Mexico
9E6	Belan, New Mexico
9E7	Caprock, New Mexico
9E8	Florida, New Mexico
9E9	Lordsburg, New Mexico
9E10	Pecos, New Mexico
9E11	Cornudas, Texas
9E12	Hueco, Texas
10E1	EMPRESA COLUMBIANA de PETROLEOS, El Centro, Columbia
11E1	EMPRESAS ELECTRICAS ASOCIADAS, Lima, Santa Rosa, Peru
12E1	ENERGIA ELECTRICA de VENEZUELA, Maracaibo, Arreaga No. 3. Station
13E1	ENGLISH ELECTRIC COMPANY, Rugby, England
14E1	ESCHER WYSS G.m.b.H., Ravensburg, Germany
15E1	ESSO PETROLEUM COMPANY, Fawley, England
	ESSO STANDARD OIL COMPANY
16E1	Belot, Cuba
16E2	Bayway, New Jersey
17E1	ESSO STANDARD OIL COMPANY OF LA., Baton Rouge, La.
1F1	FISONS LTD., Suffolk, England
2F1	FLUOR-RUNNELS GAS PRODUCTS CORP., Eunice, La.
1G1	GATES RUBBER COMPANY, Denver, Colorado
2G1	GOTLANDS POWER COMPANY, Stite, Sweden
3G1	GOVERNMENT of BAHRAIN, Manama
4G1	GRUPO INDUSTRIAL, Monterrey, Mexico
5G1	GULF OIL COMPANY, Puerto La Cruz, Venezuela
1H1	HAMMARFORSENS POWER COMPANY, Sundsvall, Sweden
2H1	HOKKAIDO DENRYOKU, Toyotomy, Japan
3H1	HUMBLE OIL & REFINING COMPANY, Baytown, Texas
4H1	HUTTENWERK RHEINHAUSEN A G, Rheinhausen, Germany
5H1	HUTTENWERK HASPE, Haspe, Germany
1I1	INDUSTRIA COLUMBIANA de FERTILIZANTES, S. A. Barranca Bermeja, Columbia
2I1	INGEN. ELECTROMECANICA (C.V.F.) Punto Fijo, Venezuela
3I1	IRANIAN OIL EXPLORATION & PRODUCING CO., Tembi, Iran
	IRAQ PETROLEUM COMPANY
4I1	Iran
4I2	Iraq
5I1	ITALCEMENTI, Bergamo, Italy
6I1	ITALIAN NAVY
1J1	JAPAN, Navy Ship
1K1	KRAFT AB GULLSPANG-MUNKFORS, Otterbacken, Sweden
2K1	KUWAIT OIL COMPANY LTD., Kuwait
1L1	LAGO OIL & TRANSPORT COMPANY, Aruba, B.W.I.
2L1	(City of) LARNED, Kansas
3L1	(City of) LETHBRIDGE, Alberta, Canada
4L1	KONIG EWALD LUDWIG MINING CIE., Haus Aden, Germany
	MANNESMANN HUETTENWERKE A. G. WERK HUCKINGEN
1M1	Huckingen bei Duesseldorf, Germany
1M2	Duisberg-Huckingen, Germany
2M1	MANUFACTURA de PAPEL C.A., Caracas, Venezuela
3M1	MANUFACTURAS METALICAS MADRILENAS, Villavered, Spain
4M1	MARTIN COMPANY, Denver, Colorado
5M1	MARUZEN OIL COMPANY, Shimozv City, Japan
6M1	MASINIMPORT, Bucharest, Rumania
7M1	MASONITE CORPORATION, Laurel, Mississippi
8M1	MATSUSHIMA MINING COMPANY, Ooshima, Japan
9M1	MENE GRANDE OIL COMPANY, San Tome, Venezuela
10M1	METROPOLITAN WATER BOARD, London, England
11M1	MINIERE et METALLURGIQUE, Rodange, Luxemburg
12M1	MINISTRY of AVIATION, Bedford, England
13M1	MINISTRY of POWER, England
	MINISTRY OF POWER/NATIONAL COAL BOARD
14M1	Rugby, England
14M2	Stoke-on-Trent, England
15M1	MISSISSIPPI CHEMICAL CORPORATION, Yazoo City, Mississippi
16M1	MISSISSIPPI RIVER FUEL CORPORATION, Bonne Terre, Mo.

CODE	OPERATING or PURCHASING COMPANY
17MI	(City of) MONROE, Louisiana
18MI	MONTANA-DAKOTA UTILITIES, Williston, N. D.
19MI	(City of) MOORHEAD, Minnesota
20MI	MULTAN, Pakistan
1NI	NATIONAL COAL BOARD, Rothes Colliery, Fife, Scotland
2NI	NATIONAL GAS TURBINE ESTABLISHMENT, Pyestock, Farnborough, England
3NI	(Ville de) NEUCHATEL, Switzerland
	NEWAG, NIEDEROSTERREICHISCHE ELEKTRIZITATSWERKE AG,
4NI	Wien, Korneuburg, Austria
4N2	Neusiedl, Austria
5NI	NIEDERRHEINISCHE HUTTE, Duisburg, Germany
6NI	NIPPON KOKAN K. K., Japan
	NORTHEASTERN POWER SUPPPLY COMPANY
7NI	Beznau, Switzerland
7N2	Weinfelden, Switzerland
8NI	NORTH OF SCOTLAND HYDRO ELECTRIC BOARD, Caithness, Scotland
	NORTHERN NATURAL GAS COMPANY
9NI	Macksville, Kansas
9N2	Tescott, Kansas
10NI	NORTHWESTERN PUBLIC SERVICE, Huron, South Dakota
11NI	NOWOKASCHIRSK POWER PLANT, Kaschira, Russia
1OI	(City of) OBERHAUSEN, Germany
2OI	ODESSA BUTADIENE, Odessa, Texas
3OI	OKLAHOMA GAS & ELECTRIC, Oklahoma City, Oklahoma
4OI	OLIN MATHIESON CHEMICAL CORPORATION, Marion, Illinois
5OI	ORLANDO POWER COMMISSION, Orlando, Florida
6OI	OSTERR ALPINE MONTANGESELLSCHAFT, Donawitz, Austria
7OI	OSTERREICHISCHE MINERALOLVERWALTUNG AKTIENGESELLSCHAFT, Schwechat, Austria
1PI	PAKISTAN INDUSTRIAL DEVELOPMENT CORPORATION, Multan
2PI	(C. A.) PARSONS, Heaton, Newcastle-on-Tyne, England
3PI	PETROLEUM CHEMICALS, INC., Lake Charles, Louisiana
4PI	PETRO-TEX CHEMICAL CORPORATION, Houston, Texas
5PI	PETROLEOS (PEMEX), Vera Cruz, Mexico
6PI	PHILADELPHIA ELECTRIC COMPANY, Philadelphia, Pa.
7PI	POTASSE et ENGRAIS CHIMIQUE, Grand Couronne, France
8PI	PUBLIC SERVICE OF OKLAHOMA, Elk City, Oklahoma
9PI	PUERTO RICO WATER RESOURCES AUTHORITY, Mayaguez
1RI	(City of) REGINA, Sask., Canada
2RI	ROYAL NAVY, England
1SI	ST. JOSEPH LIGHT & POWER, St. Joseph, Mo.
2SI	ST. PAUL AMMONIA PRODUCTS, St. Paul, Minn.
3SI	SASKATCHEWAN POWER CORPORATION, Kindersley, Canada
4SI	SAUDI NATIONAL COMPANY, Jidda, Saudi Arabia
5SI	SAUDI ARABIAN GOVERNMENT, Riyadh
	SHELL PETROLEUM,
6SI	(Brunie) Borneo
6S2	Lutong, Br., North Borneo
6S3	Tandjung, Indonesia
6S4	Venezuela
6S5	(Waiting for shipping instructions)
7SI	SHELL TANKERS "AURIS"
8SI	SHELTON IRON & STEEL CO., LTD., Stone-on-Trent, England
9SI	SIDELOR ACIERIE de ROMBAS, France
10SI	(Municipality of) SINGAPORE, Pasir Panjang Power Station
11SI	SOCIETA ELETTRICA SELT-VALDARNO, Livorno, Italy
12SI	SOCIETA ITALIANA EDISON, Italy
13SI	SOCIETA ROMANA di ELETTRICITA, Fiumicino, Italy
14SI	SOCIETATEA GENERALA de GAZ si ELECTRICITATE, Bucharest, Filaret, Romania
15SI	SOCIETE des FONDERIES de, Pont-a-Mousson, France
16SI	SOCIETE des HAUTS-FOURNEAUX de ROUEN, Grand-Quevilly, France
17SI	SOCIETE METALLURGIQUE HAINAUT-SAMBRE, Couillet, Belgium
18SI	SOCIETE METALLURGIQUE de KNUTANGE, France
19SI	SOUTH AFRICAN EXPLOSIVES, S. Africa
	SOUTHERN COUNTIES GAS COMPANY
20SI	Cactus City, California
20S2	Desert City, California
21SI	SOUTH WESTERN ELECTRICITY BOARD, Princetown on Dartmoor, England
22SI	STADTWERKE BREMEN, Vahr, Germany
23SI	STANDARD OIL OF CALIFORNIA, Richmond, California
24SI	STANDARD OIL OF INDIANA, Whiting, Indiana
25SI	STANDARD OIL OF OHIO, Lima, Ohio
	STANDARD VACUUM OIL COMPANY,
26SI	Wakayama, Japan
26S2	Palembang, Sumatra
27SI	STATE POWER BOARD, Vastervik, Sweden
28SI	STE des HAUTS FOURNEAUX de la CHIERS, Longwy, France
29SI	SUN OIL COMPANY, Marcus Hook, Pa.
	TENNESSEE GAS TRANSMISSION COMPANY
1TI	Morehead, Ky.
1T2	Alexandria, La.
1T3	Grenada, Miss.
1T4	Savannah, Tenn.
2TI	TEXACO INCORPORATED, Lockport, Ill.
	TEXAS EASTERN TRANSMISSION CORPORATION
3TI	Owingsville, Ky.
3T2	Clinton, La.
3T3	Gillis, La.
3T4	St. Francisville, La.
3T5	Athens, Ohio
3T6	Armagh, Pa.
3T7	Bechtlesville, Pa.
3T8	Bernville, Pa.
3T9	Entriken, Pa.
3T10	Grantville, Pa.
3T11	Lilly, Pa.
3T12	Perulack, Pa.
3T13	Shermans Dale, Pa.
4TI	TEXAS POWER & LIGHT COMPANY, Gainsville, Texas
5TI	TRAFIK A B, (G.O.F.) Oxelosund, Sweden
6TI	TRANS ARABIAN PIPELINE COMPANY, Saudi Arabia
7TI	TRANS-CANADA PIPE LINE LTD., Saskatchewan, Canada
8TI	TRINOIL, Trinidad, B.W.I.
	TRUNKLINE GAS COMPANY
9TI	Edna, Texas
9T2	Kountze, Texas
9T3	Premont, Texas
1UI	UCPMI, Hagondange, France
2UI	UFA, Barreiro, Portugal
3UI	UNION CARBIDE CARIBE, INC., Ponce, Puerto Rico
4UI	UNION ELECTRICA de CANARIAS S.A., Santa Cruz de Tenerife, Spain
5UI	UNION PACIFIC RAILROAD
6UI	UNION SIDERURGIQUE du NORD de la France, Escaudin
7UI	UNITED FUEL GAS COMPANY, Kenova, W. Va.
8UI	UNITED GAS PIPEING COMPANY, Napoleonville, La.
9UI	U. S. ARMY
10UI	U. S. GOVERNMENT
11UI	U. S. NAVY
12UI	U. S. MARITIME ADMINISTRATION (GTS John Sergeant)
13UI	U. S. MARITIME ADMINISTRATION & A.E.C. (Nuclear Plant)
14UI	U. S. STEEL CORPORATION, Chicago, Illinois
	(C.A.) VENEZOLANA de CEMENTOS,
1VI	Barquisimeto, Venezuela
1V2	Pertigalete, Venezuela
1WI	WESTERN CHEMICALS LTD., Two Hills, Alberta, Canada
2WI	WEST GERMAN NAVY (NATO)
	WEST TEXAS UTILITIES COMPANY
3WI	Ft. Stockton, Texas
3W2	Girvin, Texas
1YI	YNGEREDSFORS POWER COMPANY, Varberg, Sweden

GT PRODUCT NEWS

Fuel Trimmer For Turbofan . . .
Boeing's Paul M. Bradley and Lear's Norman MacMillan inspect the new Lear fuel trimmer adapter that converts basic Lear remote engine fuel trimmer system from turbojet to turbofan. It's considered virtually mandatory as a safety device on turbofans.
55

Turbine-Powered Tractor . . .
Tractor converted by Allison Division of General Motors, using Allison transmission and GMT-305 turbine. Built for ERDL-Corps of Engineers, it's being tested at Indianapolis before delivery to Ft. Belvoir.
56



Flameout Fixer . . .
Garrett's AiResearch Manufacturing Division has come up with a simple, reliable solution to turbine and turbo-prop flameouts — said to give the same re-start results as continuous ignition.
Thermostatic switch located in turbine exhaust stream remains open at normal operating temperatures . . . Below 400°F switch closes, automatically cutting in ignition for rapid re-starts.
Visual, and/or audible signal to pilot or operator may also be incorporated.
57

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MORE NEW PRODUCTS FOLLOW ►

High Quality Brazing Achieved in Compressor

Unusually close dimensional tolerances in a stainless steel compressor turbine are achieved through furnace brazing. More than 60 separate pieces are simultaneously brazed in place. Brazing is performed by Stainless Processing Division of Wall Colmonoy Corp. The turbine is produced by United Tool & Die Company for Hamilton Standard Division of United Aircraft Corporation. It is a critical component in the air conditioning system on the B-58 Hustler aircraft.

Among compressor components are nine main vanes, 18 exit guide vanes, 18 rib plates and 12 studs which are brazed into place in a pure dry hydrogen furnace at 2150°F. Vanes and rib plates are fabricated of AISI 347 stainless steel; studs are made of HS Spec 279 Type 2. Typical of the tight dimensional specifications held in the turbine assembly are these: The stud circle diameter, which is more than 5¼-in., is held to size within 0.002-in., and the turbine assembly ID is held concentric within 0.005-in. F.I.R.

58

Ring Seal For —425° to 1500°F

Just introduced by the Gits Sealing Device Division is a non-split, hydraulic and pneumatic linear-motion ring seal. Its special, all-metal construction permits use at temperatures from −425° to 1500°F. Called the Hi-Temp Ring Seal, this new Gits product was developed to satisfy increasing demand for high-temperature seals in hydraulic actuators, for high-temperature static seal applications and for high-temperature swivel joint seals.

59

High Temp Alloy A-286 is "Hot" News

An alloy which develops its best properties at 1200°-1500°F has been developed by Allegheny Ludlum Steel Corp. Known as A-286, it is an iron base alloy, for application in today's lightweight compact gas turbine engines. Operation of these engines is dependent upon rotors such as those made of this alloy by Steel Improvement and Forge Co. of Cleveland. Operation of the engine becomes increasingly efficient at high temperatures demanding use of component materials with high strength under "hot" conditions. Alloy A-286 fills the bill, having been found to have consistent and uniform forging characteristics, good heat-treat response and freedom from cracking under the stresses of forging and forming.

60

Delavan
Fuel Injectors

TOUGHER THAN TOUGH JOBS

■ Delavan specialists have broad experience in developing gas turbine fuel injectors that assure a high degree of reliability for long periods of time; that function consistently well under the most rugged conditions.

■ If you have a heavy-duty fuel injection problem consult us. Delavan engineers will develop a fuel injector that's tougher than the toughest job, hardier than the heaviest work. A Delavan injector may well reduce costs, save you valuable time or improve the performance of your equipment.

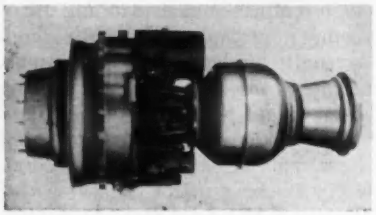
■ Delavan can bring a fund of developmental experience and manufacturing know-how that is unparalleled in the industry. Delavan is the world's largest manufacturer devoted to the design and manufacture of fuel injectors and spray nozzles.

■ *If an exacting fuel injector for gas turbines is needed . . . so is Delavan. For information write:*

DELAVAN
Manufacturing Company
WEST DES MOINES, IOWA

For more information write in No. 43

PRODUCT NEWS . . .



Continental's New 500-hp Turboshaft Engine

Continental's model 217-5A is designed primarily for rotary wing application. Currently under active development is the 2100-rpm turboprop version designated Model 217-6A, which is scheduled for a 50-hr preliminary flight rating test in April 1961. Basic engine design lends itself to modification for specific installation requirements including certain industrial uses of "Free" turbine design. In addition to the gear-reduced take-off speeds of 2100 and 6000-rpm, 35000-rpm Models will also be available. There's a 4 page brochure describing the engine that's available.

61

New SAF-LOC Coupling Assures Positive Connection

Development of the new 3750 SAF-LOC Self-Sealing Coupling for use in aircraft fuel, oil, low pressure hydraulic, pneumatic, and other systems, has been announced by Aeroquip Corporation. The coupling is especially designed to provide fast, safe connections in applications where positive, foolproof locking is mandatory.

Three check points are used to verify positive connection: 1) Sound —an audible click action; 2) Visual —indicator pins protrude externally when coupling is locked; 3) Touch —position of indicator pin can be determined manually.

Aeroquip SAF-LOC Couplings connect and disconnect with a single, easy, one-hand movement. The positive thread action of the nut gives a mechanical advantage that permits connection against line pressures ranging up to 60-p.s.i. Yet the coupling will not disconnect accidentally even under the forces applied in operation up to 20-G's.

62

SPS Pares Weight From 900°F Fastener

Lightweight version of its high strength 900°F threaded fastener has been developed by Standard Pressed Steel Co., for aircraft, missile and other elevated temperature use. Actually two new products in one—an LWB-922 bolt and companion FN-922 nut—the new high-temperature joint is 20 to 30% lighter than the pioneering TM-9 bolt-and-locknut combination that SPS introduced two years ago for applications up to 900°F. The LWB-922 bolt is forged from a 5% chromium high-strength steel alloy and finished with a diffused nickel-cadmium plating for corrosion and oxidation resistance. The 12-point head configuration and thread length are similar to those NAS series bolts. Other bolt mechanical properties include yield strengths of 185,000-psi and 140,000-psi, and minimum shear strengths of 132,000 and 100,000-psi at room temperature and 900°F, respectively.

63

New Boeing Burner Modifications . . .

Design improvements have been made in the combustion chamber burner dome and liner of the Boeing 502-series of small gas turbine engines. These recent changes have increased performance and efficiency, as well as enhanced a unique capability of the turbine to utilize various types of fuels. Now in production, new burner design was announced by the Boeing Industrial Products Division.

Use of fuels ranging from diesel and jet fuels to unleaded gasoline and kerosene, (without adjusting the fuel control system) is now possible with the new burner, according to the division's combustion engineers. Modifications of air inlets in the burner dome and liner—heart of the turbine's combustion chambers—also solve a cracking problem around air inlets and reduced the number of "cold spots" (areas below 1100°F.) which may generate harmful carbon desposits during combustion.

64

Welded Jet Engine Thrust Reversal Vanes

Welded stainless steel and super alloy tubing, (with airfoil cross-sections) directs jet engine exhaust gases for thrust reverser braking in the new General Electric CJ-805 commercial jet engine presently being used on Convair's 880. Tubing was selected for making a series of thrust reverser vanes because of its lightweight and high strength as well as ease of fabrication.

Major portion of the tubular vane, which directs the jet blast, is fabricated from type 321 stainless steel by the Standard Tube Company. Engine thrust is reversed by clamshell doors that close behind the engine proper, just forward of the sound suppressor. Reversed exhaust gases are then directed forward by these series of tubular vanes, which can be rotated to accurately control forward component of thrust.

65

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Detachable Pod Gives Boost To Navy Helicopter

An economical method of substantially increasing the speed, lift, range and versatility of newest military helicopters by use of a detachable, pod-mounted jet engine was displayed by General Electric at the American Helicopter Society's annual meeting.

This model of the Navy's newest turbine-powered utility helicopter, the Kaman HU2K, shows the J85 jet pod mounted on the side of the aircraft. The pod could be quickly attached or removed by two men. When added it could increase the helicopter's speed 40%, lift 20%, and range 17% as well as improve hovering and climb characteristics.

66

GT PATENTS

By J. W. Sawyer

WORKING MEDIUM CONTROL SYSTEM FOR A CLOSED CIRCUIT GAS TURBINE POWER PLANT (2,929,217) 5 CLAIMS John S. Collman, Detroit, Mich., assignor to General Motors Corporation, a corporation of Delaware. Concerns systems and controls for storing, supplying and withdrawing gas in closed cycle gas turbine power plants.

METHOD AND APPARATUS FOR DETECTION AND PREVENTION OF OVERSPEED AND SURGE CONDITIONS IN A COMPRESSOR (2,929,547) 9 CLAIMS John K. Koffel, Cleveland Heights, Ohio, assignor to Thomson Ramo Woolridge, Inc., a corporation of Ohio. A temperature differential-sensitive surge detection device located in the air inlet to the centrifugal compressor regulates speed of compressor turbine by control of driving medium supplied to the turbine.

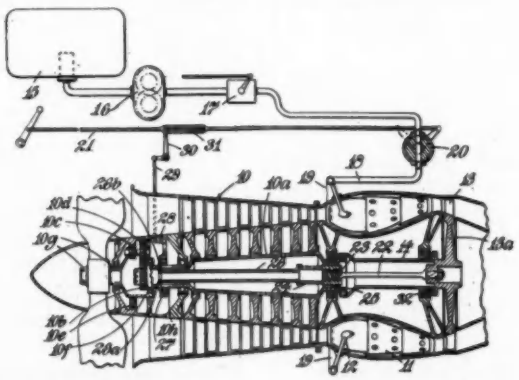
EXHAUST NOISE SILENCER (2,930,185) 14 CLAIMS John M. Tyler, South Coventry, Conn., assignor to United Aircraft Corporation, East Hartford, Conn., a corporation of Delaware. Converts normal spectrum of sound produced by the jet wake to one of higher frequency.

FUEL-AIR STARTER AND CONTROL SYSTEM (2,925,713) 11 CLAIMS Richard M. Stevens, Winsted, Conn., assignor to United Aircraft Corporation, East Hartford, Conn., a corporation of Delaware. Combustion turbine starter for aircraft engines.

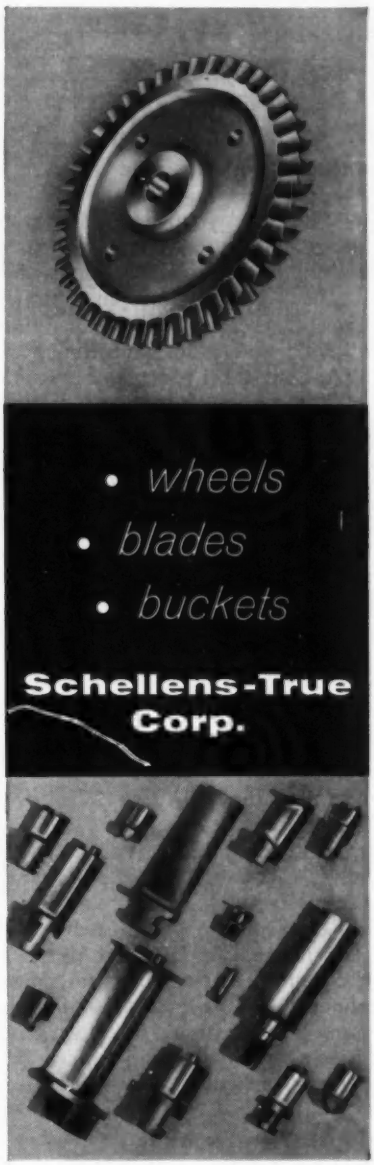
TURBINE GUIDE VANE LOCKING AND VIBRATION PREVENTING ARRANGEMENT (2,930,579) 6 CLAIMS Lawrence M. Boyd, Senneville, Quebec, and John C. McKean, Montreal, Quebec, assignors to Dominion Engineering Works Limited, Montreal, Quebec, Canada. Both ends of turbine guide vane stems are fixed in any desired position by hydraulically-operated locking device.

COMPRESSOR GROUP WITH INTERCOOLER (2,925,954) 1 CLAIM Werner Spillmann, Kilchberg and Konrad Oechslin, Zurich, Switzerland, assignors to Escher Wyss Aktiengesellschaft, Zurich, Switzerland, a corporation of Switzerland. Co-axial annular intercooler located between two axial flow compressors with saving in space and reduction of flow losses.

AIR-FUEL CONTROL IN PRE-VAPORIZER TYPE COMBUSTION CHAMBERS (2,930,191) 6 CLAIMS Robert M. Schirmer and Ellsworth H. Fromm, Bartlesville, Okla., assignors to Phillips Petroleum Company, a corporation of Delaware. The invention discloses a method and apparatus for regulating the amount of air supplied to the burner tube head in response to a change in pressure in the fuel line so as to regulate air-fuel ratio in the primary combustion zone. It also maintains vaporization of liquid fuel in the pre-vaporizer tubes to improve combustion stability of the burner configuration.



GAS TURBINE WITH SHAFT-FAILURE CONTROLS (2,930,189) 11 CLAIMS James Alexander Petrie, Littleover, England, assignor to Rolls-Royce Limited, Derby, England, a British Company. The turbine engine shown is of the propeller-driving type. If compressor rotor (10a) or shaft (14) fractures in operation, turbine rotor (13a) tends to overspeed due to loss of load and rod (22) rotates relative to sleeve (24). Sleeve is thus displaced axially relative to compressor rotor (10a). This axial displacement of sleeve (24) is arranged by suitable selection of the hand of threaded interconnection between the rod (22) and sleeve (24) to cause rocking of the bell crank in the direction to close shut-off cock (20). If failure of rear bearing (32) supporting the turbine occurs, turbine and shaft (14) will move rearwards. This movement is permitted by splined connection between shaft (14) and compressor rotor (10a). Sleeve (24) will be pulled rearwards by rod (22) to operate shut-off cock (20) and reduce fuel flow.



The Schellens-True organization is devoted exclusively to the manufacture of turbine blades, wheels, vanes and nozzles of all types, machined from a wide variety of alloys and materials. We have developed entirely special automatic blade and wheel machining equipment available nowhere else. Creative engineering, precision manufacturing and rigid quality control assure a reliable product at a minimum cost.

May we quote on your requirements?

SCHELLENS-TRUE CORP.
Ivoryton Connecticut

For more information write in No. 44

GT PRODUCT TECHNICAL FILE

Information Available On Nugent Turbine Filters

"Nugent systems filter all the lube oil in circulation every cycle, removing foreign solids 5-microns and smaller." Quoted from an information sheet specifically describing filtering systems for gas turbines.

Another sheet tells about the added protection of magnetic separation "through which the strained liquid must pass as a final stage before leaving the unit. Thus, minute ferrous particles are trapped and removed from the Fluid Steam."

67

This One's Chock Full of AiResearch Control Components

Over 2500 components for control of gas or liquid over a temperature range of —320° to 1500°F, and pressures to over 3500-psig are covered in a new catalog published by the Garrett Corporation's AiResearch Manufacturing division, Phoenix. Major items include: fuel control systems, pneumatic and electrical valves, actuators, air motors and thermostats.

Representative off-the-shelf components are listed. For each of these 300 typical AiResearch control components, complete sizing information, specifications, photographs, three-view drawings and application performance curves are given.

68

Superalloys From Kelsey-Hayes

Two new bulletins covering performance data on vacuum induction-melted Waspaloy and M-252 superalloys are available from Kelsey-Hayes Company. Waspaloy and M-252 are hi-temperature, high-stress superalloys produced by the vacuum induction-melting process. They're used in jet engines, missiles, electronic tubes and nuclear-industry applications. These two 8-pagers describe K-H's new alloy and its chemical composition—includes physical constants, tables and charts on mechanical properties, isostress curves and information on heat treatment and finishing.

69

Turbines For Electric Power

All there is to know about the Ruston "TE" gas turbine has been compiled into a special booklet from Tapco Group of Thompson Ramo Wooldidge, U.S. licensee. In it you'll find complete specifications . . . a run-down on special features . . . and some valuable on-the-job application stories about this single-shaft, 300-kw turbine designed primarily for electric power generation.

70

New Napier Pamphlets

- One describes the Gazelle, rated up to 1650-hp, admirably suited to helicopter and some industrial uses. This engine operates at any angle. Pamphlet not only includes complete ratings but a detailed cutaway of the unit.
- Another pamphlet describes the Eland, rated up to 3590-hp (3810 ehp). "Versatile Eland" is well suited to both helicopter and turbo prop installations and also some industrial uses. Various combinations of construction is also given in the pamphlet.
- "Helicopter Engines" is another pamphlet showing the applications of both the Gazelle and Eland engines.

71

Shifting Gears?

"An Advanced Concept in Modern Gears" is the title of a new 12-page booklet now being offered by the Philadelphia Gear Corporation. Fully describes advantages in using hardened and precision ground gears. New methods, facilities and applications are fully illustrated and described in detail. Highly accurate gear cutting and grinding facilities with scientific profile and flank control are described along with methods for maintaining extremely high standards of quality control throughout production. You'll find among the various applications listed for precision ground gears use in gearing for rotary wing aircraft, high-speed gas turbine drives.

72

How To Disconnect Those Accessories . . .

There's a 4-page pamphlet available from Bendix on their Accessory Disconnect—the device that allows you to disconnect accessories at any speed. Unit can be activated through electric, hydraulic, pneumatic or by mechanical means. Offers variety installation positions—integral part of your flexible drive line, or integral part of your new accessory. Pamphlet gives complete run down on this product.

73

C-B Natural Gas Compressor Teams up with P&W Jet

Cooper-Bessemer has just issued a new folder illustrating their 10,500-hp RT-248 gas turbine driven by a modified J-57 jet unit built by Pratt & Whitney Aircraft. Power unit is shown driving a C-B RF2B-30 centrifugal compressor. C-B is now developing a complete line of these power plants to include 500-hp, 3000-hp, 7000-hp, 10,500-hp and 15,000-hp. They claim their 10,500-hp unit "results in an overall 25% thermal efficiency" at full load due to the 10 to 1 compression ratio and other outstanding features of the combination unit. C-B and P&W have pioneered development of this new power concept . . . folder answers many questions we've all had about this initial installation.

74

Use your GT Reader Service Card.

New Aircraft-Missile Catalog, Aeroquip

Complete design information in a 40-page catalog for aircraft and missile tubing and duct joints is just off Aeroquip's press. Contains helpful design data and product information on joints suitable for a wide range of temperatures and pressures for gaseous, liquid and air systems . . . couplings for any fastening and sealing applications. All products shown in this new catalog are available for immediate delivery from stock in a wide range of sizes.

75

Product—Technical File

Holley Carburetor Data Available

Holley manufactures precision fuel control and other aircraft accessories for gas turbines. In a few cases these are used on turbines other than aviation. Here's a summary of some of the specification sheets available from Holley together with their application, pressure range and fuel flow capacity.

- Three specification sheets refer to Turbo-Jet Fuel Controls in Guided Missile ranging from 0-600 to 0-1500-psi and 4500 to 8100-pph.
- Seven specification sheets refer to Turbo-Jet Fuel Controls in Manned Aircraft ranging from 0-600 to 0-1500-psi and 4500 to 18,550-pph.
- One Turbo-Prop Fuel Control sheet in Manned Aircraft ranges from 0-750-psi and operates at 3900-pph.
- Another sheet covers not only Fuel Control for Turbo-Prop but also Turboshaft units together with speed governor assembly operating at 750-psi and 300-pph applicable for Manned Aircraft stationary and ground vehicle gas turbine powered.
- One sheet covers a Fuel-Air Ratio Controller. Other sheets, also primarily for Manned Aircraft cover the following Turbo-Jet controls: Compressor Bleed Control, Compressor Bleed Override Control, Bleed Piston Actuator, Overspeed Limiter and Isolation Valve.

76

Use your GT Reader Service Card.

Orenda's OT-F-2 6700-hp Turbine

New folder from Orenda illustrates their industrial gas turbine. Applications for this 6700-hp turbine—with or without heat recuperator—are shown. You'll find efficiency curves . . . plus a power plant layout showing the 2-stage gas producer turbine and the single-stage separate-shaft power turbine, all in one neatly-arranged casing. Well worth looking into.

77

(Continued on page 41)

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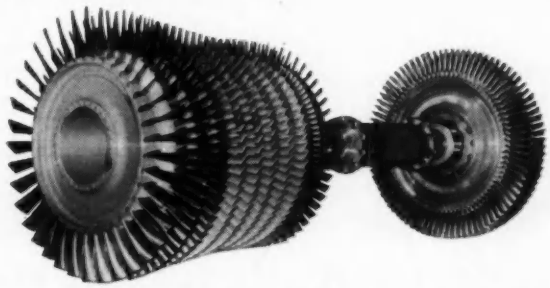
Orenda Engines Limited—the leader in the field of gas turbine development in Canada—announces the availability of a completely self-contained gas turbine powerplant for a broad range of industrial applications and burning either gaseous or liquid fuels.



This powerplant—the gas producer rotor assembly illustrated above—is backed by

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GT TECHNICAL BRIEFS

The Variable Stator Engine by Gerhard Neuman, General Manager, Small Aircraft Engine Department, General Electric Company, Lynn, Mass. (presented at the 11th Annual Flight Propulsion Meeting, Institute of Aeronautical Science, Cleveland, March 9, 1956)
Note: Though presented some time ago, this paper has been classified. Recently declassified, it is considered important enough for review now.

Since this paper was written, GE's variable-stator engines—the J59, CJ-805-3 and CJ-805-23 have accumulated over 100,000 flight hours in such aircraft as the F11F-1F, B-58, F4H, F-104, Convair 880, A3J, RB-66 and the Regulus II missile. This operational experience has proved the reliability of the variable-stator engine.

In 1952, a development project was undertaken which resulted in an engine using the variable-stator principle. It had a 17-stage single-rotor compressor with a pressure ratio of 12.2:1, driven by a 3-stage turbine.

Conclusions in the 1956 paper can be summed up as follows: The variable stator has demonstrated a major contribution in permitting stall-free operation over a wide range of *SINGLE SPOOL* engine speeds. Therefore, the variable-stator principle should be extended and further developed to solve the requirements for high-efficiency and high flow-capacity over the increasingly broad range of engine rpm encountered as progress is made toward higher flight speeds.

Analysis of Partial Admission Axial Impulse Turbines by Hans D. Linhardt, Sundstrand Turbo Div., Pacoima, California and D. H. Silvern, Consultant, North Hollywood, California, (presented at the ARS Semi-Annual Meeting, Ambassador Hotel, Los Angeles, California, May 9-12, 1960)

This is a review of the analysis and design of axial partial-admission turbines. The analysis utilizes the similarity concept of specific speed and specific diameter. Result of the analysis is presented in design charts that show efficiency lines and optimum geometric ratios as a function of the design parameters, specific speed, and specific diameter for certain regimes of Reynolds numbers and Mach numbers. Validity of the analysis is substantiated by test data. Finally, usefulness of the analysis is demonstrated by performance results of a 2-stage single-disk turbine operating on hydrazine with a flame temperature of about 2500° Rankine and which has achieved 900 specific horsepower. Successful designs of axial flow turbomachines depend to a considerable extent upon accurate knowledge and understanding of the flow in these devices.

In the gas turbine field, partial admission turbines were designed in the beginning by application of the well-established design philosophy of full admission turbines. This approach apparently was responsible for poor performance results. The paper concludes that generalized design analysis states most precisely the state-of-the-art of single-stage and 2-stage re-entry turbines. Result of the analysis is presented in general design diagrams which determine optimum range of the turbines investigated. These diagrams are most useful for solving the design problems of partial-admission.

(Continued on page 42)

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(Continued from page 39)

Bulletins From Boeing . . .

Here are some new brochures available from Boeing on their 502 and 520 turbines—brochures outlining various application possibilities for each.

18-page brochure with all the engineering dope on their 240-hp 502-10C turbine for water propulsion, the "Turbo-Mariner." And a 10-pager tells the story of the 502 as a standby steam/electric generator. If you've got a light/heat problem—shipboard or landbased—better take a look at this one. Another 10-pager gives you a complete story on the 502—100-kw emergency generator combination package.

Uses for Boeing's 520 turbine for light aircraft are outlined in a new 24-page brochure. Fixed wing . . . v/stol . . . helicopters . . . and flying platforms, turboshaft or turboprop. And there's also a new 8-pager on Boeing's turbo-starter ground support unit—for starting jet aircraft and providing for pneumatic systems.

78

Use your GT Reader Service Card.

Data On Balancing

Trouble balancing? Tinius Olsen Testing Machine Co.'s new 20-page Bulletin 60 describes two complete lines of static-dynamic balancing machines and also discusses the nature, causes and correction of unbalance with descriptions and diagrams of four different balancing methods . . . compensator, nodal bar, pivoted cradle and electrical network.

The Olsen compensator and pivoted cradle machines, as described, include special adaptations for jet engines an components, automobile engines and completely automatic balancing machines.

79

Bendix's Regulating Valve Described . . .

Specification sheet from Bendix shows how their new Regulating Valve reduces and regulates engine compressor bleed air. Includes specification of Bendix servo-operated-type throttling valve.

80

Flame Spray Described

New engineering data on flame spray processes has just been published by Metallizing Engineering Company, Inc. This 16-page bulletin covers the metallizing process that sprays powdered metals, including tungsten carbide and self-fluxing alloys of the boron-silicone, nickel, chromium-type and refractory ceramics such as aluminum and zirconia. There's also a section devoted to the new Metco Plasma Flame Spray process which develops unusually high temperatures and can spray any material that can be melted without decomposition. This new bulletin covers basic engineering considerations for each process . . . includes tables and charts on specific characteristics of these coatings, such as hardness, tensile strength, bond strength, etc.

81

Hi-Temp Materials . . .

New pamphlet from Bendix details their Product Divisions work on ceramics, cermets and metals. Also includes a sheet on bearings and seals . . . another on abradable castings which are claimed to "provide a low cost product for gas turbine engine compressor and turbine shrouds."

82

From AiResearch . . .

Graphs on their GT P70 and GT C85 series illustrate reduction in operational delay rates . . . and increase in time between overhaul periods. Lot of good solid information is here that's well worth knowing.

Interested in constant-speed drive starters? We've word of a new brochure from Garrett Corporation's AiResearch Division that features their CSDS 200-1. You'll find all the details in there, down to the last flange bolt. Specs and frequency control graphs, performance curves and electrical system—it's all there.

83

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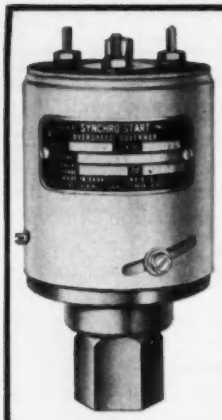

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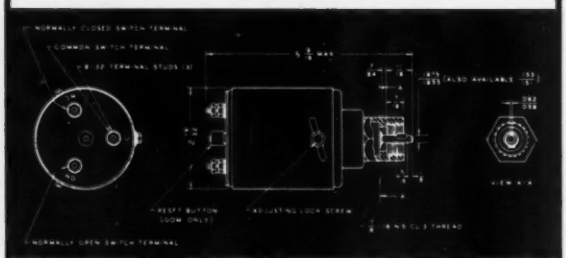

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TECHNICAL BRIEFS . . . (Continued from page 40)

Development Experience with Prototype Gas Turbines by J. E. Cook, Standard-Vacuum Oil Company, White Plains, N. Y. (No. 60-GTP-13, ASME, Gas Turbine Power Conference, Houston, Tex., March 6-9, 1960)

In 1956 Standard-Vacuum Oil Company built fluid catalytic-cracking plants in two Asian refineries, using four identical 3000-hp gas-fired turbines to drive main air blowers and gas compressors. A newly-designed, unproven gas turbine was purchased for this application. This paper describes major field problems encountered and modifications necessary to put the unit into commercial operation. Severe blade damage due to sulfur in fuel gas, fouling of combustor air baffles, thrust bearing failure, axial-compressor fouling, and effects of high ambient temperatures were experienced and corrected by the co-operative effort of manufacturer's and owner's field personnel.

The author's conclusion states "with this experience behind us and with a fuller understanding of the capability and limitations of the machines, the company is looking forward to an extended period of reliable and economic power for cat-plant air blowers of this capacity. *Economic utilization of waste-fuel products is a strong incentive for pioneering.*"

Comparison of Operating Characteristics of a Two-Shaft Gas Turbine With a Single-Shaft Gas Turbine for Gas Line Pumping by M. J. McDonough, Design Engineer, Industrial Gas Turbine Department, Westinghouse Electric Corporation, Philadelphia, Pa. (No. 60-GTP-17, ASME, Gas Turbine Power Division Conference, Houston, Tex., March 6-9, 1960)

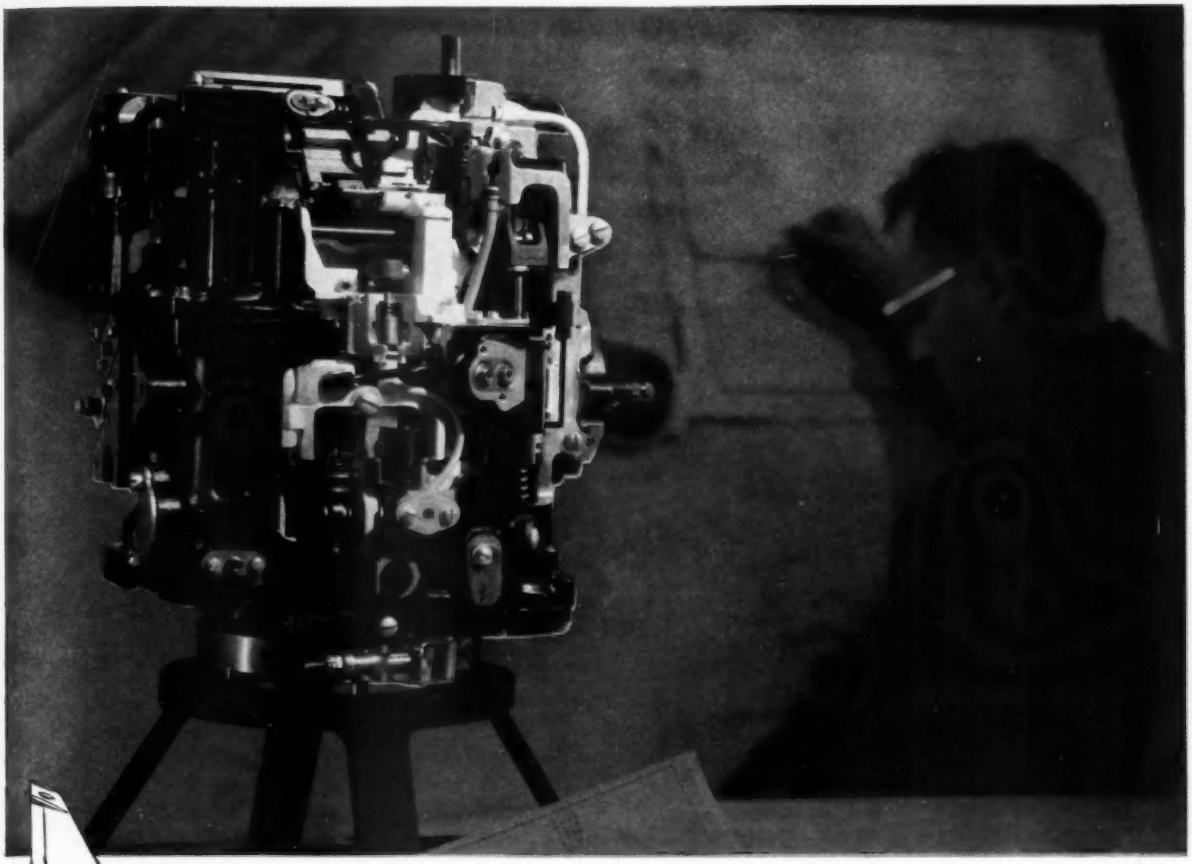
Gas turbines are playing an important role in the ever-expanding gas-transportation industry. Coupled to a centrifugal compressor the gas turbine provides a low-cost, flexible prime mover for gas transmission. Two types of gas turbines most commonly used in this field are the single-shaft unit and the two-shaft unit. This paper describes and compares operating characteristics of each unit along a typical centrifugal-compressor loading line for constant station discharge pressure. Horsepower-speed relationship and specific fuel consumption are considered in this comparison.

Furthermore the author states in his conclusion "There are applications for both types of gas turbines depending upon the gas-line load factor. For low load-factor lines the two shafts would generally be the choice and for high load-factor lines the single-shaft gas turbine is preferred because of its simplicity and good efficiency."

Economics of the Steam-Gas Turbine Exhaust-Fired Cycle for Medium-Size Utilities by M. Eisler and W. M. Sybert, Kaiser Engineers, Oakland, California. (No. 60-GTP-15, ASME, Gas Turbine Power Conference, Houston, Tex., March 6-9, 1960)

All electric utilities are faced with the problem of optimizing the addition of new generating units to provide adequate capacity as predicted by the loadgrowth forecasts. Smaller capacity additions permit closer matching of the load-growth curve but larger units have a lower capital cost per kilowatt. Conflict between installing small generating units at a high capital cost per kilowatt or larger units at a lower kilowatt cost but resulting in excess system capacity is particularly acute for the small and medium-size electric utilities.

For these systems, the combined steam-turbine gas-turbine fired-exhaust cycle may be of special interest. This cycle permits a "building-block" approach; *i.e.*, the gas turbine can be added to a new or an existing steam station at an optimum time, allowing deferment of the next steam-turbine installation. This building-block concept permits closer matching of the load-growth curve with all the advantages of the combined plant as an additional benefit.



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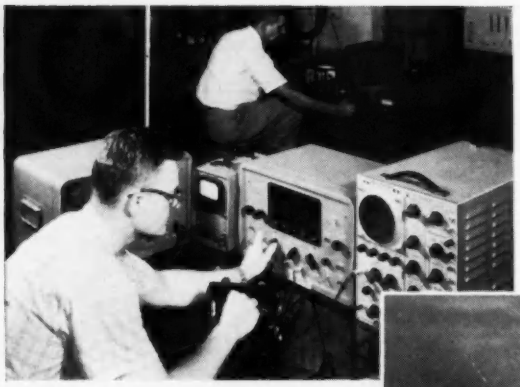

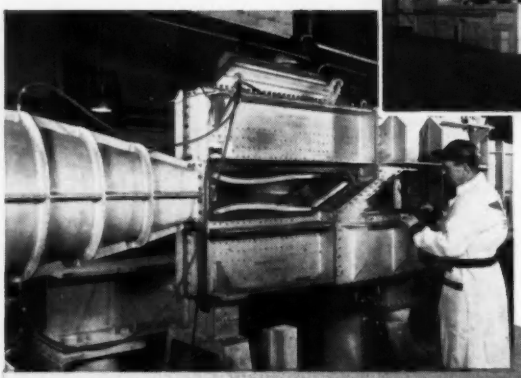

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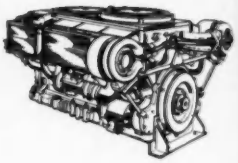

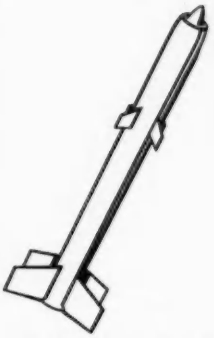

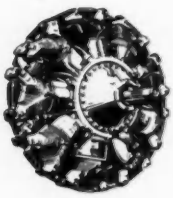

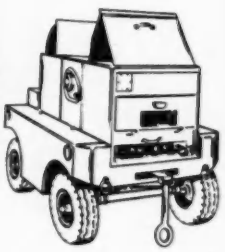

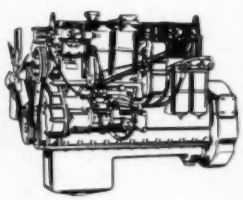

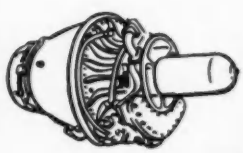

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